THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. II.

No. V.—MAY, 1895.

ORIGINAL ARTICLES.

I.—Notes on the Geology of Mashonaland and Matabeleland.

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Introduction.

THE history of the Zambesian territories now known as "Rhodesia" is extremely meagre. Of the country prior to the advent of the Matabele in 1838, little is known, except from the few records, chiefly Portuguese, that have been preserved. It should be mentioned, however, that an interesting link between the Sofala and the Zimbabwi ruins near Victoria exists in certain gold tacks or rivets, possibly used in the manufacture of gold ornaments, which have been found in both these places, while we believe that at intervals along a route to the coast, ruins of towers have been found, that in all probability have been used as stations on the way.

That Zimbabwi, near Victoria, and similar ruins in other parts of Central South Africa are relics of the greatest antiquity, is generally accepted, and it is also probable that a search after gold was the main object of the adventurous and enterprising people, not South African, who were in possession. The massive structure of the ruins, laboriously composed of regular square granite blocks, not much larger than bricks, together with the general design and elaboration, foreign to Negro creations, impress one with the idea that a masterful invading race dominated the enslaved aborigines.

One portion of the Zimbabwi ruins of Victoria was probably a temple, the other a stronghold or keep such as might have been necessitated by the partial and unstable nature of the sway exercised by the invaders.

It is probable that in later times, even within the last century, the Portuguese had settlements in Mashonaland, and that they both carried on mining operations themselves, and traded for gold won by the natives. In the north, at Tete, on the Zambesi, alluvial gold can still be purchased from the natives. The gold is collected by them in reeds.

The later facts of history are briefly as follows :—Mosilakatse, driven from the Transvaal by the Boers in 1837, crossed the Limpopo, and by dint of his warlike propensities, and the valour of his Zulu followers, established in the course of three years a mastery over the greater part of Central South Africa between the Limpopo and Zambesi Rivers, creating the Matabele supremacy. This supremacy he and his son and successor, Lobengula, maintained until the series of events following the formation of the British South African Company culminated last year in the Matabele war, the overthrow of Lobengula, and the occupation of Matabeleland by the adventurous and plucky 800 who advanced to Buluwayo.

Topographical and Physical Features.

The area of Matabeleland and Mashonaland, now consolidated, is upwards of 135,000 square miles. The territory has no seaboard. The nearest coast is that of Mozambique, Sofala being about 108 miles, and Beira 160 miles from the border. The eastern boundary as regards Portuguese territory has not yet been finally agreed upon. It is probable that it will be about the 33rd degree of east longitude, with a tongue projecting westward to include Masse-Kesse in Mozambique. Some distance south of Masse-Kesse the boundary trends westward, ending about the intersection of the Limpopo River and 32 east longitude. The western boundary of Matabeleland proper is indefinite, but the Chartered Company's rights, so far as the British Government is concerned, are co-extensive with the British sphere of influence, between the Limpopo and the Zambesi, exclusive of Bechuanaland, reaching as far as longitude 25 E. The backbone or "hogs-back" of the country is formed by an irregular belt of high plateau land, or high "veldt" as it is termed in South Africa, with an altitude varying from 3500 to 5000 feet. This belt, embracing the most salubrious portions of Matabeleland and Mashonaland, stretches from south-west of Buluwayo, in a north-easterly direction to Umtali in Manicaland, passing just north of Victoria, but including Salisbury. It forms the main divide of the river systems of the country, being the source of the tributaries of the Limpopo or Crocodile River and the Sabi River on the south, and those of the Zambesi on the north.

There can be no doubt that the country is on the whole well-watered; and although many of the smaller streams are mainly replaced by broad beds of sand in the dry season, still the traveller can scarcely ever be said to suffer from scarcity of water, either for his own needs or for his cattle.

Geological Structure.

That the physical features of a country are to a large extent dependent on the geological formations which compose it, is nowhere better illustrated than in Mashonaland and Matabeleland. The rocky structure is remarkable for its uniformity over large areas;

in like manner the scenery and physical characters are strikingly persistent. Sedimentary deposits are of rare occurrence. The great bulk of the country is granite, the remainder being formed chiefly of metamorphic rocks; the whole doubtless constituting a portion of that ancient floor of granite and metamorphic rocks that elsewhere underlie the subsequent sedimentary or igneous accumulations. It is of course possible that this vast area of granite and metamorphic rocks was at one time wholly or partially covered by detrital deposits; but if so, they have been subsequently denuded and only in isolated instances do any traces of them still remain. Sandstone deposits with workable beds of coal are said to occur near the Zambesi, north of Buluwayo. Sandstones, grits, and conglomerates are also reported to occur in the Victoria district, but under what geological conditions we are unable to say. In any case, however, we can state that the major portion of the surface of the country is underlaid by granite rock forming broad expanses of flat or rolling veldt, from which rise occasionally huge agglomerations of immense boulders and fantastically shaped kopjes, the home of the despised Makalakas and Mashonas, where they were used to seek refuge from the raids of the Matabele. At intervals, too, the granite rises into rugged mountain ranges with rude broken outlines, and scored and scarped bosses of bare rock, as for instance in the Matoppo Hills, south of Buluwayo.

Turning now to the metamorphic rocks or schists which constitute the gold belts of the country, we find them occurring as broad bands and patches in the granite. In passing from an area of granite to one of schist the traveller is struck by the contrast presented by the two types of scenery. The country loses its bare and rugged aspect; the contours become soft and more undulating or even hilly; the soil, hitherto sandy and sterile, becomes clayey and fertile; the hills are covered with trees, and give rise to numerous streams; and in some of the districts (the Seleukwe and Victoria) the alternation of thickly wooded hills with fertile valleys forms scenery that would be noted for its beauty in any country. To what geological conditions may these differences in scenic or physical features be ascribed? We think the more broken character of the schist country is due to the variable nature of the component rocks, and to the fact that they are turned up on edge, rendering them more susceptible to the attacking forces of atmospheric disintegration.

The Origin of the Gold Belts.

In discussing the origin of the auriferous rocks, a series of interesting questions present themselves for solution.

1. What is the geological relation of the schist to the granite?
2. Why are the auriferous veins chiefly confined to the schist belts and their immediate neighbourhood?
3. Is there any community in origin between the veins and the schists?

We will endeavour to find answers to these questions. The rocks

composing the metamorphic series are chiefly chlorite and hornblende schists, with which are associated epidiorites, actinolite rock, diabases, dolerites, and other basic igneous rocks. The intimate association of basic igneous rocks with the schists was a fact we have had ample opportunity for noting, and our observations lead to the conclusion that the schists have been derived in great measure from those rocks, and that their foliated or schistose structure has been produced by a mechanical process analogous to "shearing" and referable to certain movements of the earth's crust along zones of fracture or weakness.[1]

The sequence of events in the formation of the schists would be somewhat as follows:—The granite crust acted upon by enormous lateral pressure and tension produced by shrinkage, folding, and rucking would tend to develop main lines or zones of strain, weakness, and fracture, through which the molten basic magmas hitherto pent up within the earth's crust would be forced up to form dykes and intrusive masses of igneous rock along these zones. The earth-movements, continuing along the main lines of fracture, would effect the mechanical metamorphism of these rocks to schist, and perhaps simultaneously cause the formation of open fissures; and these, offering a free passage to mineralizing solutions, would give rise to the quartz lodes that form the auriferous deposits of the country. It is reasonable to suppose that a portion of the granite would also be involved in the zone of movement; and indeed we find evidence of this in the fact that gneiss or foliated granite is generally found on the margin of a schist belt or within the belt itself.

Transitions from an unaltered igneous rock to a highly foliated unctuous schist are clearly discernible in many parts of the gold belt. The minute structural and mineralogical changes involved in the transition can be best studied with the aid of a microscope. Starting, say, with a dolerite or diabase, the gradation of change will be roughly as follows:—Dolerite being a rock composed of plagioclase felspar and augite, the first step is the conversion of the augite to hornblende. This is one of the most common changes in the whole range of petrology. Augite and hornblende are practically identical in chemical composition, but have a different crystalline structure. Hornblende is, however, more stable than augite at ordinary temperatures; consequently the first results of molecular rearrangement in rocks containing augite is the paramorphism of that mineral to hornblende. The rock produced by this joint change consists therefore of plagioclase felspar and secondary hornblende, and is known as an epidiorite.

The next change is a breaking down of the felspar, producing a granular aggregate of quartz and reconstructed felspar, and a rolling out of the hornblende into ribbons or folds. This process, known as foliation, produces a hornblende schist. The metamorphism progressing, the hornblende becomes replaced by chlorite,

[1] See W. Gibson, Quart. Journ. Geol. Soc., vol. xlviii, p. 404; also A. R. Sawyer, *ibid.* vol. l, p. 144.

and the rock is sheared into the highly foliated and unctuous slaty rock known as chlorite schist.

A similar process of metamorphism acting in acid igneous rocks, gives rise to sericitic (mica) schist, but these are of much rarer occurrence than the basic schists in the gold belts of Mashonaland. It is in the regions of most intense metamorphism that the veins occur. In the great majority of cases, therefore, the country rock of the lode is chlorite schist. In a few cases the veins occur in gneiss, but we are not aware of any instance in Mashonaland or Matabeleland of a lode having been found in the granite.

We are now in a better position to answer the questions previously stated.

1. The relation of the schists to the granite is probably one of original intrusion in the form of basic igneous rock, and not of deposition of sedimentary beds on the top of a granite floor.

2 and 3. The auriferous veins are chiefly found in the schist belts or their immediate neighbourhood, because they owe their origin to a sequence of dynamic phenomena intimately connected with those that gave rise to the schists themselves.

A corollary of great importance for the future of the Mashonaland gold-fields can be deduced from the foregoing, namely: That the schist belts are continuous in depth, and are not liable to be cut off by the granite, as has been maintained on the assumption that they were sedimentary deposits resting on a granite floor.

Gold-bearing Districts.

There is a rude parallelism in the direction of the schist belts, their trend being roughly east and west across Matabeleland and the southern portion of Mashonaland; and it is an interesting fact that similar schist belts (also auriferous), occurring in Zoutspanberg, have the same general trend. Travelling up from Tuli to Buluwayo, three belts of schist are traversed. The first is encountered some 45 miles north of Tuli; it is a small strip of metamorphic rock three to five miles wide. The next is the newly-discovered Gwanda belt lying 60 to 70 miles south of Buluwayo. This is a fairly broad belt, being 8 to 10 miles in width, while westward it trends towards the Tati gold-fields, and eastward it probably connects with the belt known as the Naka pass. Schists also occur for some 20 miles south of Buluwayo, and it appears probable that belts trending to the coast connect with the Victoria gold-fields. Travelling eastwards from Buluwayo several regions of metamorphic rocks are passed, the most important being those of Bembise, Shangani, Seleukwe, Gwailo, etc. The principal districts visited by us are the Mazoe, the Umfuli, Victoria, Umtali, Mogundi, and the Seleukwe.

The camp of the Mining Commissioner of the Mazoe district is about 27 miles north of Salisbury. The limits of the metamorphic area round the upper Mazoe are in no direction well defined. Southwards the geological features of the country are to a great extent obscured by a heavy surface wash, but it seems very probable that between the Mazoe and Salisbury there is a continuous schist

and slate formation, and that the Mazoe and Salisbury districts are practically one. Eastwards of the Commissioner's camp there are at least five or six miles of schists and greenstones, while westward the schists extend for about ten to twelve miles without interruption. To the north-east along the Mazoe river for about 30 or 40 miles a number of claims were marked out in the early part of 1891. Most of these, however, have since been abandoned, and little further prospecting has been done in that direction. The whole Mazoe district from a few miles north of Mount Hampden, which is twelve miles from Salisbury, is broken and hilly, varied by stretches of flat pasture land and swamps along the river sides. The direction of the hill ranges is, roughly speaking, north-east and south-west, but the numerous spurs and frequent branching off of one range into another make any detailed description of the contour of the country as impossible as it would be uninteresting. Many of the veins in the Mazoe district traverse igneous rocks. The Vesuvius Reef is a dark bluish quartz, separated by from one to two feet of clay selvage from the country rock, which may be called felspar porphyrite. The Alice Reef occurs in a coarse basic crystalline rock, the immediate wall of the vein being altered so as to present a schistose structure. Other veins occur in chloritic and other schists, and appear in the majority of cases to follow the foliations of the country rock.

In this connection we would remark, as it may give rise to some discussion on the vexed question of classification, that we do not consider that the fact of a vein following the general direction of foliation of the country rock, militates against the existence of a true fissure, or argues any lack of permanency of the vein in depth.

What is known as the Umfuli district comprises a number of smaller tracts in the neighbourhood of the Umfuli River in Mashonaland. The intervening country may yet in parts be proved to be auriferous.

The Hartley district extends about 11 miles from the Umfuli along a flat stretch of country, uninterrupted save by the two or three granite kopjes known as the Hartley Hills. The eastern portion of the district, including several of the best known reefs, is granitic and gneissose. Westwards on both sides of the Umfuli, gneiss gives place to schists and clay slate.

Concession Hill, where developing operations are now being carried on, lies 16 miles west-south-west of Hartley. The central ridge of this and the adjoining Duchess Hill is a body of chert and jasper, 40 to 50 feet thick on Duchess Hill, and reaching 100 feet or more on Concession Hill. Parallel bands of the same rocks are found along the flanks of the hills, alternating with chloritic schists and slates. The formation dips south-west at an angle of more than 70 degrees. In the Duchess Hill, where a shaft has been sunk 100 feet and cross-cuts driven, gold is found to occur in the chert bands chiefly in the form of thin scales or flakes; and similarly in Concession Hill, though here the gold is associated more with

quartz and highly ferruginous veinstuff. Much of the gold in the Concession Hill deposit is visible to the naked eye, occurring in a kind of arborescent crystalline form resembling a pattern of seaweed. On the south-west side of the hill there is an old stope from 2 to 5 feet wide and reaching a depth of 50 feet in hard rock. In this stope an iron pick was found in such good preservation that it hardly seems likely that the working is of very ancient date, and the same may be said in other cases in which timbers showing but little decay have been found at depths of 30 to 40 feet, or where waste dumps occur neither overgrown nor to any extent mixed with soil.

Speaking generally of old workings in Rhodesia, the general impression of those who have studied them is that they can be assigned to no one period; some say there were three distinct periods, but there seems to be little evidence for so precise a conclusion. We saw no old shafts near the workings on Concession Hill. It seems probable to us that in many cases the old miners did not hoist mineral, but carried it up inclined foot-roads, along the strike of the veins, as is done in Mexico and other less advanced mining countries to this day.

The town of Victoria is on the Pioneer Road from Tuli to Salisbury and about 180 miles south of the capital. The new township is rather more than a mile outside the actual gold belt, being in the granite country lying to the north. The average width of the schist formation may be taken roughly as between 10 and 11 miles. The greatest breadth is from Victoria towards Fern Spruit and the Tokwe River, where it reaches a breadth of 20 miles. The belt extends probably, as already stated, as far as Buluwayo in Matabeleland. It has certainly been traced from the western boundary of Mashonaland some 70 miles eastwards beyond the Umbelique River, and there seems little doubt that it continues to the Sabi River, if not further. The main body consists of chlorite and hornblende schists, together with diabasic and hornblendic igneous rocks. Talcose schist and steatite also occur, and towards the Tokwe River strongly foliated gneisses are found. The general dip of the foliation is southerly, the strike being east and west. Mr. Wybergh has favoured us with the following section across the belt from Victoria to Zimbabwi, a distance of 15 miles. First, a small band of chlorite and talc schists with beds of steatite is crossed. Then follows a small bed of ironstone and quartzite, succeeded by three miles of decomposed schists. Beyond this the formation is described as sandy, massive beds of sandstone occurring with seams of conglomerate (at Willoughby's Camp). The district generally is hilly, in parts mountainous, and is on the whole well covered with bush and well watered.

Umtali lies south-east of Salisbury, from which it is distant about 140 miles by road. From Chimoio, the present railway terminus, it is distant 55 miles, and from Beira 200 miles. The schists of the auriferous belt have been traced from Mozambique westwards to beyond the Odzi River, say 35 miles west of Umtali. The width

of the belt varies from one to two miles at the western end, to ten in the eastern portion. The chief interest in the district centres in the Penhalonga Range, a sharp ridge commencing a few miles east of Umtali, and extending six or seven miles towards Masse-Kesse. The backbone of the ridge is a bed of hard banded quartz rock and ironstone, the formation of the range gradually consisting of various metamorphic schists; in places soft talcose steatitic and chloritic varieties prevail, while in other parts a harder quartz-felspathic type occurs. Just west of the highest point of the ridge (the Crow's Nest) the formation is broken through by a belt of igneous rock (diabase or dolerite) which forms a cross spur constituting the divide or watershed between the Revue and Umtali Rivers, on the north side of the ridge, and giving rise to the Zambesi on the south side. The principal reefs of the district are the Rezendi and Penhalonga, the latter famous on account of the deposits of chromate of lead in brilliant red crystals, which characterize the best portions of the reef. The Umtali district is among the healthiest as well as one of the most beautiful parts of Mashonaland.

One of the properties of the Victoria District Gold Mining Company is situated on Victoria Creek, about twelve miles south of Victoria. The vein strikes N.N.E. and S.S.W., dipping at 35 degrees to 45 degrees to the W.N.W., which is opposed to the dip of the schist foliation, which is about 50 degrees east. The walls of the vein are formed by chlorite schist, a rock of wide occurrence in the district. The vein sheet is of irregular or lenticular character, varying considerably in width in different places. The mineralized portion of the vein consists of a band of dark-coloured quartz, brown in the oxidized and hydrated portions, but elsewhere grey. The colour is due to the presence of iron in various combinations, hematite and limonite being the minerals of greatest influence in the colouration of the quartz. Besides these minerals there are also present iron-pyrites, copper-pyrites, malachite, azurite, and gold. The pay band varies from four to five feet down to a few inches. It is easily distinguished from the unpayable quartz by the difference in colour, the latter being white. The mine has been opened by a main incline shaft down 130 feet, from which drifts have been carried on the 55 and 115 feet levels; drifting on the first level amounts to 400 feet, and on the second to 106 feet.

The Cambrian Reef is situated in the eastern portion of the Victoria gold belt, about 50 miles from Victoria, and close to the Shashi River. The reef consists of a quartz vein in gneiss formation, which towards the Shashi changes to hornblende schist and basic igneous rocks. The strike of the vein is parallel to the foliation of the gneiss, viz. S.E. and N.W. It dips at a high angle to the N.E. The outcrop is bold, forming a rocky kopje apparently indicating a reef of considerable breadth. There is little doubt, however, that the apparent size of the outcrop is increased by the reef having fallen over, away from the dip side, as erosion of the country rock proceeded. The vein-filling material is mainly white

quartz, but there are also seams of dark grey and brown quartz. The coloured quartz owes its colour to the presence of iron minerals and indicates a greater amount of mineralization than the white portions. The gold occurs mainly in patches, chambers, pockets, and crevices in the reef, and many good specimens of "visible" metal can easily be obtained by a little search.

The Dunraven property in the Seleukwe district contains a number of quartz lodes, some of which are roughly parallel, others intersecting to form a network of veins. The workings are approached by an adit run in from the side of the hill; above, on the hill side, are some extensive old workings. Several reefs of considerable dimensions have been discovered in the adit, and these are now being driven on. The gold is free and is associated with the usual iron and copper minerals.

The Inez Reef in the Mombi district is one of the best known in the country. It is traceable at or near the surface for a distance of a mile or two, striking N.W. and S.E., and dipping S.W. The best part of the reef is a shoot, extending 100 feet along the strike, and to the greatest depth yet attained, viz. about 90 feet. The average width of reef here is 6½ feet, with a grade of probably nearly 1½ ozs. per ton (by fire assay). A crushing of 40 tons from the best part of the reef yielded 68 ozs. on the plates—34 dwts. per ton. The quartz is compact with for the most part little mineral, the gold being fine and apparently evenly disseminated. Near the hanging wall, however, there is sometimes a vein from 2½ to 14 feet in thickness, heavily charged with antimonite, and antimony ochre; the sulphide is massive and almost pure. The hanging wall of the reef is chloritic schist. The footwall is metamorphic, but of more obscure character; the rock is often granular in texture and contains secondary calcite.

The Camperdown property is in the Seleukwe district, Matabeleland. The particular hill on which the property is situated is composed chiefly of banded chert and ironstone, similar to Concession and Duchess Hills. Interbanded with the country are veins or seams containing sugary quartz and iron oxides, which carry gold, and have been worked by the ancients through numerous pits and burrows on the rabbit-warren method. It is probable that a number of different seams have been worked at shallow depths, the workings extending promiscuously along and down the hill side. Another class of deposit on the Camperdown is the fissure vein, with very high dip. In one part of the hill it would appear as if both kinds of deposits had been worked together. A long vertical stope can be seen with traces of quartz on the walls, which at one point is enlarged into a shaft about 15 to 20 feet deep to tap one of the flat-lying interbanded deposits.

Near the Camperdown, as in fact in all the gold districts of the country, are to be seen the stones used by the ancients for grinding quartz. They are generally blocks of the harder varieties of rocks, from 20 to 100 lbs. in weight, with shallow depressions worn into the upper face. Sometimes near a river, mortars can be seen, hollowed out of the solid rock.

Since the recent re-discovery of the Ayrshire Reef, it has been prospected by four or five shafts at irregular intervals along the strike. The first shaft was put down through an old working and into solid rock to a depth of 45 feet from the present surface, or to a total depth of about 60 feet below the normal surface of the country. This shaft has now fallen in, but a new one has been sunk alongside of it to a depth of 55 feet. The second shaft was sunk in a vein of felspar which eventually dipped out southwards, but was intersected by a cross-cut at 55. On each side of the felspar vein is diorite very rich in gold; it assays from 2 to 20 ozs. and even in parts 160 ozs. to the ton. This remarkable, if not unique, occurrence of gold was made the subject of a communication to the Geological Society by Mr. Alford last year.[1] He had sections cut, and states that the reef was in a quartz-diorite. In another shaft, 1000 feet from the first, the diorite is again exposed, but prospecting had not been carried far enough when we visited the property to prove the extent of the deposit. A general sample taken across the bottom of the shaft assayed 11 dwts. Since then a cross-cut has been driven to the felspar vein which outcrops in the old working in which the shaft was sunk, and the report is that the diorite has here again proved extremely rich. The reef seems to be a dyke of diorite traversing the granite or gneiss, which is the predominating country rock, in an easterly and westerly direction. The width of the diorite is nowhere proved, nor even the extent to which it is auriferous. It would appear that the gold, more or less, hugs the felspar vein, occurring on either side of it. The felspar vein is found throughout the length of the workings: apparently one persistent vein which would in this case be a valuable index to the best part of the deposit. The felspar contains only traces of gold.

Alluvial Deposits.

With regard to alluvial deposits we are permitted to quote from Mr. Hammond's Report to the Chartered Co. that "As far as my examination extends I could see no evidence of alluvial or placer deposits; in fact the topographical character of the country visited by me is such as to almost preclude the possibility of the occurrence of alluvial deposits of any extent or importance. This statement refers to those portions of Mashonaland and Matabeleland which I examined. In Manicaland the topographical conditions are different, favouring the occurrence of auriferous alluvial deposits of limited extent. I saw some of those deposits which had been worked by the ancients. The probability is that such deposits as have occurred have been, for the greater part, already worked out."

Conclusions.

Prospecting in Rhodesia is made easy for the present generation, for, with the rather remarkable exception of the Victoria district, practically all the known mineral areas of the country show evidence

[1] Quart. Journ. Geol. Soc. vol. l, p. 8 (Proc.).

of having been the field of former mining operations. Probably 90 per cent. of the reefs known at the present day have been previously exploited at one time or another; that the Victoria gold belt should be an exception is remarkable, lying as it does in close proximity to the best known and most extensive ruins in the country. The fact seems, in the absence of explanation, rather to go against the generally accepted theories with regard to Zimbabwi and gold-mining; or, as has been suggested, with, to our mind, small ground, it may be that old workings exist in the district, that are now filled up and have been concealed by natural agencies.

The general method of prospecting in a new district is to get hold of the natives in the neighbourhood, and by practical persuasive arts, in which beads and salt play an important part, to make them act as guides to the holes and depressions that mark the position of old workings. Sometimes an outcrop has been left, but more often the old workings are the only indication remaining. Having pegged off a line of old holes and as much of the extension as he feels inclined to incorporate with it, the intelligent prospector proceeds by panning from the old dumps and loose quartz lying about, and, by a critical examination into the relative sizes and depths of the overgrown holes, to select a site for his shaft. The object naturally is to strike the reef where, from the evidence at hand, it is likely to present a good section, and in this the prospector is so often successful that if such first strikes could be taken as a gauge of the average grade of the reefs, there could be no doubt whatever of immense future prosperity to the mining industry of Rhodesia.

While the majority of reefs pegged in the country will probably never yield one sovereign for two that are sunk in them, it would be extraordinary indeed, considering the great number of reefs proved to exist, if there were not some prizes in the lottery. They may be few and big, or few and mediocre, or they may be many, but to condemn or extol the country, as a whole, in its present stage of development, would be in our minds rash and prejudiced. Given a proper discrimination in the selection of properties, and the exercise of judgment in the expenditure of capital, the country certainly commends itself to the attention of capitalists.

The immediate future of mining in Rhodesia, and in fact the immediate future of Rhodesia itself, depend almost entirely on the success of gold-mining. Silver is of comparatively small importance. We say the immediate future, for, whatever the mineral prospects of Southern Zambesia may be, we have small doubt that in the course of a few decades, possibly half a century, the country will, with its healthy and fertile uplands, support a considerable population on its pastoral and agricultural merits alone.

II.—On the Liassic Fish *Osteorachis macrocephalus*.

By Arthur Smith Woodward, F.L.S., F.G.S.,
Of the British Museum (Natural History).

(PLATE VII,[1] Fig. 10.)

Among the fishes of the Lower Lias of Lyme Regis, Dorsetshire, described by Egerton from imperfect evidence, is the genus *Osteorachis*, with the single species, *O. macrocephalus*.[2] The original description and figure are so unsatisfactory that nothing beyond the name of the fish is quoted even in Zittel's "Handbuch" (vol. iii, p. 230), while this bears an appended query; and the author's definition of the genus is certainly much too vague to admit of any precise determination of its systematic relationships. Under these circumstances it is of interest to return to a consideration of the fish in the light of more recently discovered specimens, which seem to the present writer to comprise not only examples of the trunk but also, at least, one satisfactory head.

The type specimen, now in the British Museum, is shown only in a general way in Dinkel's drawing, and Egerton's description is far from explanatory. It comprises the imperfect head with the greater portion of the trunk obliquely crushed and exposed from below. Remains of a large gular plate appear between the fragments of the smooth mandibular rami; and there are clusters of small, remarkably slender, hollow teeth. The premaxilla cannot be identified with certainty, but one obscure portion of bone seems to show the bases of a single close series of larger teeth; another fragment, exposed from its oral face, must have originally borne at least three series of the typical small teeth. On one large expanded bone, which may be entopterygoid, the teeth cover an extensive area and are in part merely fine granulations. The hyomandibular is well shown on one side, but in Dinkel's drawing it is not distinguished from an adjoining element which appears to be the displaced metapterygoid. The process of the hyomandibular for the support of the operculum is long, but its hinder end is connected with the upper and lower extremities of the element by a thin lamina of bone. Behind the hyomandibular, parts of the operculum and suboperculum are seen from within. The vertebral centra are not "completely ossified," but are represented merely by distinct hypocentra and pleurocentra; their arches are obscurely indicated through the displaced squamation. The tubercles on the scales are occasionally elongated, and on the hinder portion of some of the flank-scales they are observed to pass into transverse striæ which terminate in feeble denticulations. The fins are too fragmentary for detailed description.

Some further account of the characters of the trunk and fins of *Osteorachis* is given by Egerton from another specimen, now in the British Museum (No. P. 3655). The structure of the head, however, has never been more precisely indicated. The opportunity is now afforded to supply this deficiency by a fossil from the Lower Lias of Lyme Regis, preserved in the Oxford Museum. This is a skull,

[1] For this Plate (VII) see the April Number Geol. Mag.

[2] Quart. Journ. Geol. Soc. vol. xxiv (1868), p. 500, and Figs. and Descript. Brit. Organic Remains, dec. xiii (Mem. Geol. Surv. 1872), no. 5, pl. v.

proved to belong to *Osteorachis* by its characteristically clustered slender teeth; and the writer is indebted to Professor A. H. Green, F.R.S., for facilities to make a detailed study of it.

The specimen in question is preserved in indurated Lias, and much fractured by crushing. It is laterally compressed, and at the same time somewhat distorted, so that the jaws on the left side are opened and parts of the inner dentition are exposed. This left side presents the features of greatest interest, and it is shown of two-thirds the natural size in Pl. VII, Fig. 10. The cranium itself is too imperfect for description, but its roof is observed to have been in part very finely tuberculated. There is an ossification in the postfrontal (sphenotic) region (*pt.f.*), and the same remark applies also to the prefrontal (lateral ethmoidal) region (*p.f.*). The orbit in the fossil is occupied by a fragment of the ossified sclerotic (*scl.*). The cheek is shown to have been completely covered with plates to the border of the preoperculum, and several of these exhibit traces of a very fine tuberculation, while other portions are more coarsely rugose. Two very large *postorbitals* (*pt.o.*) are distinct, and there are also remains of a *circumorbital ring* (*c.o.*). Within these fragments above the maxilla can also be seen portions of a large thin smooth plate, which is not improbably the *entopterygoid*. The *maxilla* (*mx.*) is long and slender, fractured in two places, and either destroyed or obscured at its anterior extremity. It is stout in front, thin and slightly deepened behind, with its outer surface partly smooth, partly rugose. Its hinder third is overlapped by a small elongated *supramaxilla* (*s.mx.*) which is deepest posteriorly, acutely pointed in front, and exhibits a finely tuberculated external surface. Its oral border is nearly straight for the greater part of the length of the element, but there is a downward trend behind, perhaps exaggerated in the fossil by the accidental splitting of the bone. Its teeth are all long and slender, nearly of equal size, well spaced and arranged in a single series. They are enamelled to the base and distinctly hollow. The *premaxilla* (*p.mx.*) is only obscurely indicated, but extends for a considerable distance along the oral margin, and bears probably not less than ten long slender teeth, similar to those of the maxilla; seven of these teeth are preserved. The left mandibular ramus, showing the high coronoid region, is also fragmentarily preserved, and the *dentary* (*d.*) bears a single series of teeth, like those of the margin of the upper jaw, and not exceeding the latter in size. Most of these teeth are displaced or broken away, and cross-sections of the bases of some are exposed. The great interest of the jaws, however, centres in the streak of clustered dentition both immediately below the maxilla and immediately above the mandible, but distinctly internal to each. The teeth of these clusters are shown to be exactly similar to those on the margin of the jaw, but much smaller and more closely arranged; and they all appear to be readily broken off the bones supporting them. The upper cluster (*ecpt.*) doubtless pertains to the ectopterygoid, while the lower cluster (*spl.*) may be referred with certainty to the splenial. Between the rami of the mandible there are remains of a large gular plate (*gu.*) in front, and a few branchiostegal rays (*br.*) behind.

The characteristic inner teeth not only serve to identify the skull

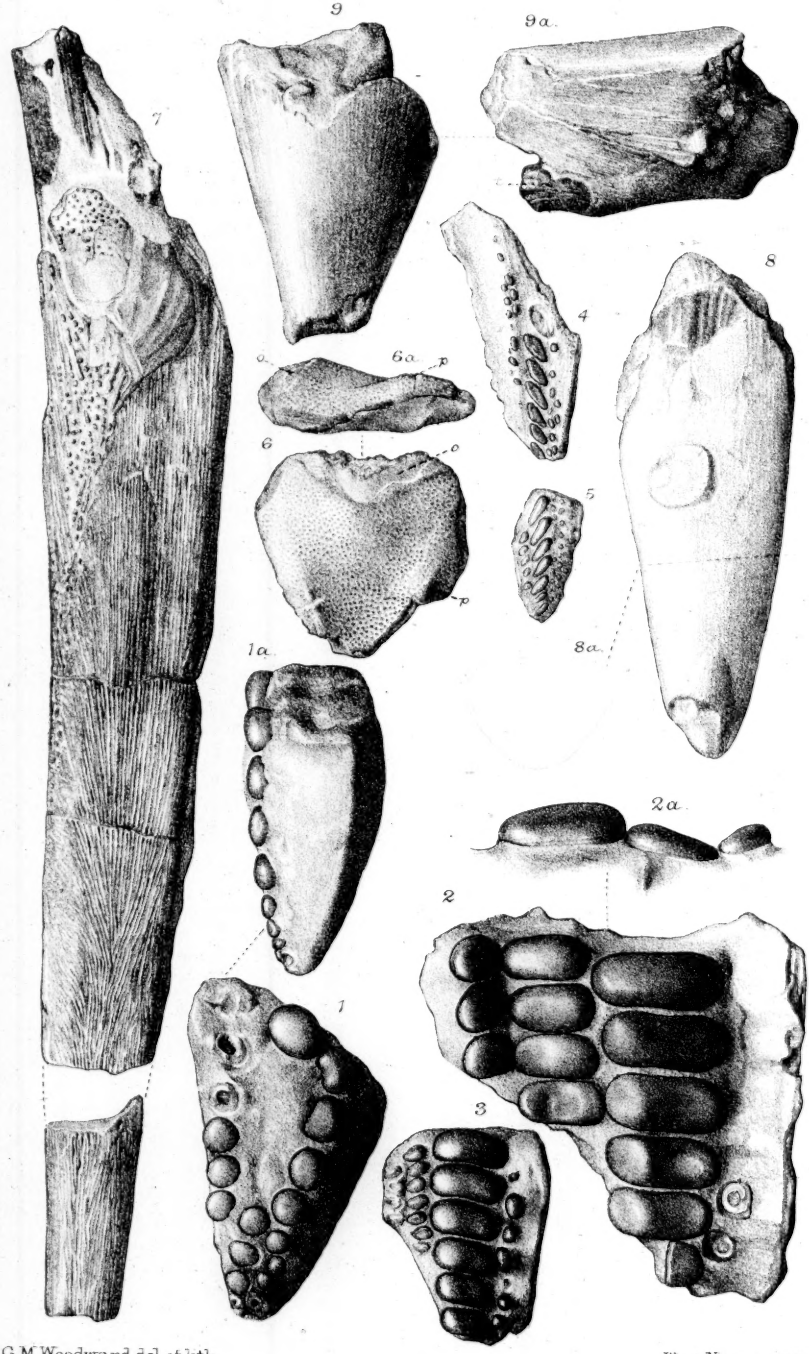
just described, but also seem to necessitate the reference of two other specimens from Lyme Regis to *Osteorachis*, and probably to *O. macrocephalus* itself. These are imperfect fishes bearing the names of *Harpactira velox*[1] and *Heterolepidotus grandis*,[2] each about a metre in length, the first in the British Museum and the second in the Davis Collection, Halifax. They not only exhibit the teeth, but also remains of the typical squamation; and they are important as making known the greater part of the fins.

Harpactira velox has never hitherto been satisfactorily determined; and, remembering that the unique example of this fish displays neither vertebral elements nor ossified vertebral arches, there may still be some hesitation in accepting its identification with *Osteorachis*. The great amount of disturbance, however, to which the specimen has been subjected is indicated by the fact that the left suboperculum is displaced to the hinder part of the caudal region. Moreover, we may cite another example of a fish from the Lias of Lyme Regis in which the fins remain in position, while nearly the whole of the well-calcified series of vertebral arches is wanting (*Chondrosteus acipenseroides*, Brit. Mus. No. P. 3367). The present writer is thus convinced that the evidence of teeth and scales must outweigh all other considerations; and a careful comparison of the original specimens compels him to relegate the name *Harpactira velox* to the synonymy of *Osteorachis macrocephalus*. This unique type fossil exhibits the imperfect head obliquely crushed, and the greater part of the right mandibular ramus is exposed from the inner aspect. The dentary is much fractured in front, though showing the coronoid elevation behind; while the splenial is displaced, but sufficiently complete to display its clustered small slender teeth and the excavation of its hinder margin. Some of the characteristic teeth are also scattered below the jaw. The right hypohyal occurs; and the large gular plate is completely preserved, this being two-thirds as broad as long, obtusely rounded in front, truncated behind. The exposed portion of the suboperculum is slightly more than twice as broad as deep, ornamented with a very fine and close tuberculation; and there is a small ascending process at its antero-superior angle. Scales occur sparsely in the region of the pelvic, dorsal, anal, and caudal fins, all exhibiting a fine tubercular ornamentation. On the few principal flank-scales which are preserved, the tubercles have a tendency to elongation and pass in the hinder half into conspicuous striæ. The peg and socket for articulation are very large, as usual. The ventral scales are shown to have been narrowed, as also are those immediately covering the base of the caudal fin-rays.

Scales of the form just described are much better preserved in the so-called *Heterolepidotus grandis* of Davis; and the fins of both the specimens in question are apparently identical in general characters and disposition with those of the genus *Eugnathus*. It is not yet known, however, whether the fulcra in *Osteorachis* were biserial or uniserial.

The result of these further comparisons therefore is, that *Osteorachis macrocephalus* belongs to the same family as *Eugnathus*, and is generically distinguished from this fish by the enlargement of the inner clustered teeth, and the comparative tenuity of its scales.

[1] Egerton, Geol. Mag. Dec. II, Vol. III (1876), pp. 441, 576.
[2] J. W. Davis, Journ. Linn. Soc. Zool. vol. xviii (1885), p. 293, pl. vii.



G.M. Woodward del. et lith. West, Newman imp.

Cambridge Greensand Ganoids.

III.—A Synopsis of the Remains of Ganoid Fishes from the Cambridge Greensand.

By Arthur Smith Woodward, F.L.S., F.G.S.,
Of the British Museum (Natural History).

(PLATE VIII.)

THE remains of fishes discovered in the Cambridge Greensand are all very fragmentary, and have not hitherto been subjected to the detailed comparison with other Cretaceous Ichthyolites which their interesting stratigraphical position renders desirable. Many specimens, however, are capable of at least generic determination, while many others are sufficiently characteristic fragments for the definition of the species. The present writer has thus been much interested during the past few years in studying collections of these fossils, and the following notes embody some of the results in reference to the ganoid fishes. The British Museum (Natural History) having recently acquired the collection made from the Cambridge Greensand by Mr. Thomas Jesson, F.G.S., nearly all the known species are now represented here; but the writer has also availed himself of the privilege of making use of the fine series in the Woodwardian Museum, Cambridge, and the Philosophical Society's Museum, York, thanks to the kindness of Professor McKenny Hughes, Mr. Henry Woods, and Mr. H. M. Platnauer. Mr. James Carter, M.R.C.S., has also kindly lent some Pycnodont jaws from his private collection.

Genus Lepidotus, Agassiz (?).

A few scales identical in form with those of the genus *Lepidotus*, showing the produced angles of the overlapped portion, are contained in the Jesson Collection (Brit. Mus. No. P. 7232). The largest measures about 0·03 m. in the depth of its exposed area. They all seem to have been smooth, but a small boring organism has destroyed much of the surface.

Family PYCNODONTIDÆ.

Genus Athrodon, Sauvage.

The genus *Athrodon* has already been recorded from the Cambridge Greensand on the evidence of an abraded splenial bone; and there is some reason for also assigning to it a vomer with seven irregular longitudinal series of teeth, in the Woodwardian Museum.[1] A second species is now indicated by another splenial in Mr. Jesson's collection, and this appears to be distinct from all forms hitherto described.

1. *Athrodon crassus*, A. S. Woodward, Geol. Mag. Dec. III, Vol. X, (1893), p. 435, Pl. XVI, Fig. 3.

Type. Right splenial: Woodwardian Museum, Cambridge.

[1] A. S. Woodward, Geol. Mag. [3] Vol. X (1893), p. 435, Pl. XVI, Fig. 4.

2. *Athrodon Jessoni*, sp. nov., Pl. VIII, Figs. 1, 1*a*.

Type. Right splenial: British Museum (Jesson Collection).

Splenial bone very robust, but narrower than in *A. crassus*, with large, closely-arranged smooth teeth, mostly circular, disposed in three nearly regular longitudinal series. Anteriorly the three series are about equal in size; posteriorly the median teeth are slightly the larger.

The dentition on the type, and only known specimen, measures 0·02 m. in maximum width and 0·04 m. in length. The seven teeth of the innermost series are well preserved, except the foremost, and the hinder four are very slightly longer than broad. There is a small supplementary tooth within anteriorly. Of the median series, three round teeth remain in front, and then only one at the hinder end, this being slightly broader than long. The three middle teeth of the outer series are preserved, and behind these are the bases of two others; they are nearly equal in size to the teeth of the inner series, but not antero-posteriorly elongated.

Genus Cœlodus, Heckel.

Cœlodus is also represented by two specific types of splenial dentition; and two forms of vomer in the Woodwardian Museum may perhaps be placed here.[1] The first species, already described, seems to be tolerably common; while the second species is as yet known only by the unique fossil described below.

1. *Cœlodus inæquidens*, A. S. Woodward, Geol. Mag. Dec. III, Vol. X (1893), p. 491, Pl. XVII, Fig. 5.

Type. Left splenial: British Museum (No. 36157).

2. *Cœlodus cantabrigiensis*, sp. nov. Pl. VIII, Figs. 2, 2*a*.

Type. Right splenial: British Museum (Jesson Collection).

A large species known only by the splenial dentition. Teeth on the splenial bone smooth; those of the principal series scarcely more than twice as broad as long, and nearly equal in width to the two flanking series; inner flanking teeth twice as broad as long, and twice as broad as the teeth of the outer series, which are scarcely broader than long; a row within the principal series represented by few small teeth.

Though relatively gigantic, this form of dentition is almost identical with that of the Wealden *Cœlodus Mantelli*. Even the almost unworn teeth in the Cambridge Greensand fossil, however, are destitute of any trace of the deep apical indent characteristic of all the Wealden teeth; there need thus be little hesitation in regarding the present form as specifically distinct. The front teeth of the type specimen figured are deeply excavated by wear during the life of the animal; and the inner supplementary teeth are indicated only in front by two bases.

[1] A. S. Woodward, *loc. cit.* 1893, p. 492, Pl. XVII, Figs. 3, 4.

Genus Anomœodus, Forir.

A large form of splenial dentition from the Cambridge Greensand has already been provisionally ascribed to *Anomœodus*, and it is now possible to add undoubted evidence of a diminutive species of this genus, besides a more doubtful example of a medium-sized form.

1. *Anomœodus superbus*, A. S. Woodward, Geol. Mag. Dec. III, Vol. X (1893), p. 489, Pl. XVI, Fig. 5.

Type. Left splenial: Woodwardian Museum, Cambridge.

2. *Anomœodus confertus*, sp. nov. Pl. VIII, Fig. 3.

Type. Imperfect right splenial: collection of James Carter, Esq.

Teeth on splenial bone very closely arranged, and none except perhaps the outermost with apical pit; those of the principal series not more than twice as broad as long, truncated at each end, their long axis directly transverse, and their antero-inner point very feebly turned forwards; inner teeth in a single irregular series of moderate size, and each slightly longer than broad; those of the innermost flanking series scarcely as large as the latter, somewhat broader than long, and irregularly oval [outer flanking series unsatisfactorily known].

The type specimen is the best fragment of this species hitherto observed by the present writer, and the outer margin of the splenial thus remains to be discovered. The dentition seems to most closely resemble that of *A. Muensteri*, but is readily distinguished by the proportions of the principal teeth.

3. *Anomœodus Carteri*, sp. nov. Pl. VIII, Fig. 4.

Type. Right splenial: collection of James Carter, Esq.

A small species known only by the splenial dentition, which is well spaced. Teeth of principal series very obliquely set, pointed at each end, not more than half as long as broad, and when unworn with a slight transverse coronal furrow; outer and inner teeth very small and irregular, with crimped apical pit, none broader than long, but the majority longer than broad; inner teeth with tendency to arrangement in two series; flanking teeth in about three series of approximately equal size.

The type specimen, shown of natural size, from the oral aspect in Pl. VIII, Fig. 4, exhibits the outer toothless border of the splenial element characteristic of the genus *Anomœodus*; and this well-preserved fossil is completely divested of matrix. On its inner face there is a longitudinal groove for the reception of the persistent meckelian cartilage. A second fragmentary specimen in Mr. Carter's collection is similar; and a third example of the splenial in the York Museum (Pl. VIII, Fig. 5) only differs in small particulars. In the latter the innermost teeth are relatively large and with obliquely directed long axis; while the flanking teeth, which are partly obscured by matrix, are arranged in three comparatively regular series.

This form of splenial dentition most nearly resembles that of *A. angustus*, but is distinguished by the form and proportions of the flanking teeth.

Family EUGNATHIDÆ.

Genus Lophiostomus.

This genus has hitherto been found only in the Chalk, and but a single example of the skull is known. It is thus of great interest to record the discovery of two fragments of the cranium in the Cambridge Greensand, which evidently pertain to a new species.

Lophiostomus affinis, sp. nov. Pl. VIII, Figs. 6, 6*a*.

Type. Occipital half of cranial roof: Brit. Mus. (Jesson Collection).

As shown by the figures which represent the upper and right lateral aspects, the imperfect fossil on which this species is founded indicates a skull of similar form and proportions to that of the typical *L. Dixoni*. The superficial ornament, however, consists of finer elongated tubercles; while the frontal prominence (*p.*) on either side is very slightly elevated compared with that of the typical species. The occipital border is preserved, showing a broad smooth surface of overlap (*o.*); and this border is not straight but somewhat excavated by a re-entering angle. No certain indications of sutures between the component elements can be observed.

The second specimen, in the Woodwardian Museum, Cambridge, shows exactly the same portion of the cranial roof with identical characters, but is also interesting as preserving the occipital region. As in the preceding specimen, there is no trace of a prominence on the squamosal, such as appears to be present on the right side of the only known skull of *L. Dixoni*. The cartilages of the occipital and otic regions are well ossified, and there is a deep conical fossa in the articular face of the basioccipital. There are indications of a deeply jagged median suture between the frontal bones, but otherwise the limits of all elements are indistinguishable.

Family ASPIDORHYNCHIDÆ.

Genus Belonostomus, Agassiz.

This genus is represented in the Cambridge Greensand not only by fragments of the characteristic presymphysial bone, but also by portions of the skull and scales. Two imperfect scales in the Woodwardian Museum are as large as those of the Australian species, *B. Sweeti*, and similarly ornamented; while the portions of skulls are of two kinds, one equally large, the other comparatively small and depressed.

Only the hinder half of the skull is preserved in each case. Of the larger form there are four examples in the Jesson Collection (Brit. Mus. No. P. 7235), measuring from 0·04 m. to 0·05 m. across the post-frontal region, and all exhibiting the robust ossification of the otic elements. The basisphenoidal region is much laterally compressed, but no sutures can be observed between any of the

bones, and even those of the cranial roof seem to be fused into a continuous shield. The latter is elaborately ornamented with closely-arranged, vermiculating rugæ and tubercles.

The smaller form of skull, known only by two specimens in the Woodwardian Museum, is much depressed and scarcely exceeds 0·02 m. in width across the post-frontal region. The cranial roof is likewise rugose, but exhibits very clearly the limits of the parietal and frontal bones. The parietals are much elongated antero-posteriorly, united by a wavy suture and bordering the hinder extremity of the frontals with their antero-external production. The interdigitations of the mesial frontal suture are especially deep and conspicuous.

Family PACHYCORMIDÆ.

Genus PROTOSPHYRÆNA, Leidy.

Perhaps the commonest remains of ganoid fishes met with in the Cambridge Greensand are portions of the rostrum of *Protosphyræna*. Not only are they abundant as specimens; they are also of more varied form than the corresponding fossils met with in any other English Cretaceous horizon. In fact, if the rostrum alone suffices to characterize the species of *Protosphyræna*, as is commonly assumed and as seems probable, no less than five new types can be distinguished among these specimens. The typical species, *P. ferox*, also occurs, and the characters of all of them may be briefly summarized as follows:—

1. *Protosphyræna ferox*, J. Leidy, Trans. Amer. Phil. Soc. vol. xi (1857), p. 95. Woodcut, Fig. 3.

Rostrum much elongated and attaining a length of about 0·3 m., with a transverse diameter of 0·05 m. at its base where the vomerine teeth are implanted; circular in transverse section throughout its whole length (Figs. 3*b*, *c*), except within a short distance of the vomerine teeth, where it becomes slightly flattened on the upper part of its sides and the top (Fig. 3*a*) and passes into the gradually widening flattened cranial roof; its external surface ornamented with reticulating rugæ, of which the most prominent are longitudinally directed.

2. *Protosphyræna tenuirostris*, sp. nov. Woodcut, Fig. 1.

Type. Rostrum: Woodwardian Museum, Cambridge.

Rostrum much elongated and slender, somewhat flexed upwards shortly in advance of the vomerine teeth, and attaining a length of about 0·24 m., with a transverse diameter of 0·027 m. at its base where the vomerine teeth are implanted; transverse section (Figs. 1*a*–*c*) remarkably cylindroidal throughout its length, slightly depressed in its middle portion; external surface marked by fine longitudinal ridges.

A slightly more attenuated form of rostrum from the Cenomanian

of Kursk, Russia, probably of this species, is ascribed to "*Saurocephalus striatus*, Ag." by V. Kiprijanoff, Bull. Soc. Imp. Nat. Moscou, vol. xxxiii, pt. i (1860), p. 666, pl. x, fig. 3.

3. *Protosphyræna Keepingi*, sp. nov. Woodcut, Fig. 4.

Type. Imperfect rostrum: Woodwardian Museum, Cambridge.

Rostrum remarkably stout and short, circular in transverse section, only slightly flattened on the top at its base (Fig. 4*a*); external surface ornamented with reticulating rugæ.

This species is known only by the unique type specimen obtained by Mr. Henry Keeping.

4. *Protosphyræna ornata*, sp. nov. Pl. VIII, Fig. 7.

Type. Imperfect rostrum: Woodwardian Museum, Cambridge.

Rostrum much elongated and attaining a length of about 0·2 m., with a transverse diameter probably of 0·02 m. or 0·025 m. at its base where the vomerine teeth are implanted; vomerine area elongated, and the rostrum much laterally compressed, except towards its attenuated distal extremity, which is round in section; the rounded upper contour of the rostrum gradually becoming raised into an obtuse median longitudinal ridge at its base and ornamented with coarse rugæ, which frequently subdivide into tubercles and are mainly longitudinal in direction though partly turned obliquely downwards; the lateral portions ornamented with much finer longitudinal rugæ, which tend in part to converge at the middle of the side and form a slight median longitudinal ridge on the inferior aspect for some distance in advance of the vomerine area.

This appears to be the commonest species of *Protosphyræna* in the Cambridge Greensand, and the rostrum is readily distinguished both by its lateral compression and the unique ornamentation. The type specimen, shown of the natural size from the left lateral aspect in Pl. VIII, Fig. 7, is the finest example hitherto discovered.

5. *Protosphyræna depressa*, sp. nov. Pl. VIII, Fig. 8.

Type. Rostrum: Woodwardian Museum, Cambridge.

Rostrum comparatively short and depressed, its length apparently not exceeding 0·055 m. in a specimen measuring 0·025 m. in transverse diameter where the vomerine teeth are implanted; upper aspect flattened, almost hollowed, and the sides converging below so that the transverse section (Fig. 8*a*) appears triangular with rounded angles; surface smooth or in part slightly rugose.

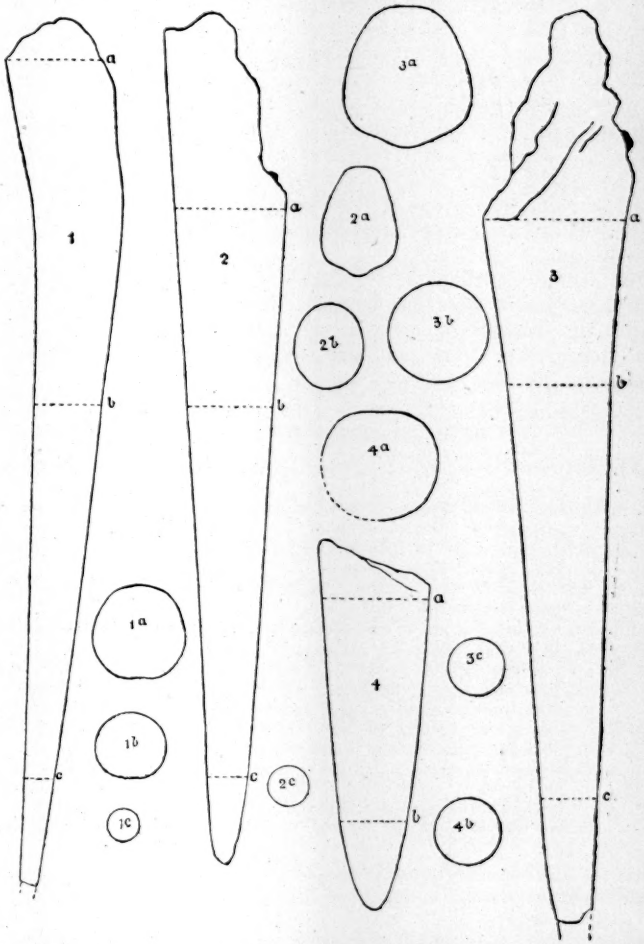
6. *Protosphyræna brevirostris*, sp. nov. Pl. VIII, Figs. 9, 9*a*.

Type. Base of rostrum: British Museum (Jesson Collection).

Rostrum comparatively short and acute, its length apparently not exceeding 0·05 m. in a specimen measuring 0·025 m. in transverse diameter where the vomerine teeth are implanted; upper aspect and sides flattened, the latter converging below in a median inferior

keel, making the transverse section triangular at the end of the vomerine region; surface nearly smooth.

This species has already been incidentally mentioned in discussing



Outlines of Rostra of *Protosphyræna* in lateral aspect and transverse section, one-half natural size.

Fig. 1. *Protosphyræna tenuirostris*, sp. nov.—Cambridge Greensand. [Woodwardian Museum, Cambridge.]

Fig. 2. *Protosphyræna compressirostris*, sp. nov.[1]—Kentish Chalk. [Brit. Mus. No. P. 5631.]

Fig. 3. *Protosphyræna ferox*, Leidy.—Kentish Chalk. [Brit. Mus. No. P. 5630.]

Fig. 4. *Protosphyræna Keepingi*, sp. nov.—Cambridge Greensand. [Woodwardian Museum, Cambridge.]

[1] This species may be characterized thus: Rostrum much elongated, and

the affinities of *Protosphyræna*,[1] and is specially remarkable on account of the shortness of the snout. The type specimen exhibits apparently the greater part of the ethmoidal region, and wants only the extremity of the snout. On the obscured inferior aspect there are traces of the large, laterally-compressed vomerine teeth (Fig. 9*a*, *t*,) and there appears to be no flattened area in advance of them. The transverse section is shown to be triangular as described, and on the upper surface there seem to be some feeble indications of coarse longitudinal rugæ partly subdivided into tubercles. A second, more abraded specimen (Brit. Mus. P. 7252) has a slightly larger and longer snout with a triangular flattened area immediately in front of the vomerine teeth; but the differences it presents are not greater than such as may be reasonably explained by individual variation.

The ganoid fish fauna of the Cambridge Greensand is thus almost as unique as its reptilian fauna. Nearly every fragment which admits of satisfactory comparison, differs specifically from allied fossils occurring elsewhere; and the number of forms represented is also remarkable.

EXPLANATION OF PLATE VIII.

Fig. 1. *Athrodon Jessoni*, sp. nov.; right splenial, from the oral and symphysial (1*a*) aspects. [British Museum, No. P. 7238.]

Fig. 2. *Cœlodus cantabrigiensis*, sp. nov.; right splenial, from the oral and hinder (2*a*) aspects. [British Museum, No. P. 7236.]

Fig. 3. *Anomœodus confertus*, sp. nov.; right splenial, oral aspect. [Collection of James Carter, Esq., F.G.S.]

Fig. 4. *Anomœodus Carteri*, sp. nov.; right splenial, oral aspect. [Collection of James Carter, Esq., F.G.S.]

Fig. 5. Ditto?; anterior end of left splenial, oral aspect, partly obscured by matrix. [Reed Collection, York Museum.]

Fig. 6. *Lophiostomus affinis*, sp. nov.; hinder portion of cranial roof from the upper and right lateral (6*a*) aspects; *o*. overlapped occipital border; *p*. prominence above orbit. [British Museum, No. P. 7233.]

Fig. 7. *Protosphyræna ornata*, sp. nov.; imperfect rostrum, left lateral aspect. [Woodwardian Museum, Cambridge.]

Fig. 8. *Protosphyræna depressa*, sp. nov.; rostrum, upper aspect, and transverse section (8*a*). [*Ibid.*]

Fig. 9. *Protosphyræna brevirostris*, sp. nov.; imperfect rostrum from the upper and left lateral (9*a*) aspects. *t*. vomerine tooth. [British Museum, No. P. 7253.]

All the specimens were obtained from the Cambridge Greensand, and the figures are of the natural size.

attaining a length of at least 0·19 m., with a transverse diameter of 0·02 m. at its base where the vomerine teeth are implanted; laterally compressed in its proximal half, the transverse section here being an oval with vertical long axis (Fig. 2*b*); circular in transverse section in its distal portion (Fig. 2*c*); the top of the base gradually becoming flattened as it passes into the cranial roof. External ornament as in *P. ferox*.

[1] A. S. Woodward, "On the Affinities of the Cretaceous Fish *Protosphyræna*," Ann. Mag. Nat. Hist. [6] vol. xiii (1894), p. 510, footnote.

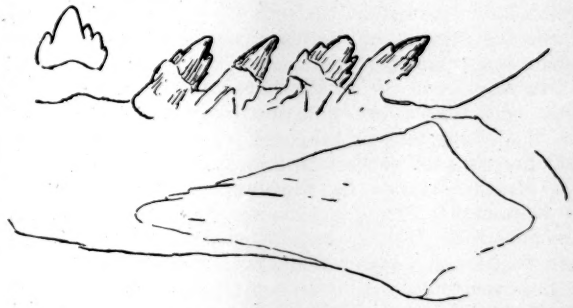
IV.—On the Occurrence of *Phoca rugosidens*, Owen, in Maltese Strata.

By John H. Cooke, F.G.S., F.L.S.

In a memoir which was read before the Geological Society of London in 1870, and which was published in the Proceedings of that Society and in the Malta papers, Dr. A. A. Caruana[1] makes mention of a portion of a rib and of a lower jaw of a mammal which were obtained from the Globigerina Limestone at El Kbajer, near Kolla el Baida, in the island of Gozo; and after referring to the fact that no Carnivora had, up to that date, been found in the Maltese Islands, he described the El Kbajer fossils as being "a portion of the lower jaw of a Hyæna with several teeth *in situ*."

The fossils were presented by Dr. Caruana to the University Museum, Valetta, and for nearly twenty-three years they remained there, labelled "Remains of Hyæna."

In the year 1890, I drew the attention of Dr. John Murray to the remarkable description which was attached to these specimens; and in 1891 I entered into correspondence with, and forwarded sketches and photographs of the remains to, the late Prof. van Beneden, of Louvain. Both of these eminent geologists confirmed my suspicions as to the mistake into which Caruana had fallen.



Right mandibular ramus of lower jaw of *Phoca rugosidens* (Owen); Globigerina Limestone, Gozo, Malta. The original is preserved in the University Museum, Valetta. The tooth drawn in outline shows the form of the cusps of a single detached molar.

The principal specimen, which is firmly embedded in a compact block of Globigerina Limestone, consists of the right ramus of the lower jaw of a *Phoca*. It contains three entire molars, and a portion of a fourth. All of them are *in situ*; and they are in a capital state of preservation. The enamel of the teeth is very rough; and the margins are boldly though unequally serrated on both sides. One of the molars, situated towards the posterior extremity of the jaw, clearly exhibits the bifurcation of its roots. This is the finest specimen of the remains of a fossil Seal that has yet been recorded from the Maltese Islands.

[1] Caruana, A. A., Quart. Journ. Geol. Soc., vol. xxvi, p. 434; "Malta Observer," March, 1870.

While hunting for further evidences of these animals in the same locality as that whence this fossil was obtained, I was fortunate enough to find an isolated molar in the bed which is situated between the first and the second nodule seams, and from information which I obtained as to the exact locality in which the Malta University specimen was obtained, as well as from a comparison of its matrix with the rocks at El Kbajer, there can be no doubt but that they were both obtained from the same horizon. The molar tooth found by myself shows the lower portions of its bifurcated root. It measures $\frac{1}{2}$ an inch in length, and $\frac{3}{8}$ of an inch in breadth. The enamel is rough and uneven, and it is scored with white striations of unequal lengths, which run in parallel lines longitudinally down both sides of the tooth. Along the posterior margin there are two very pronounced serrations, while on the anterior margin, and in immediate juxtaposition with the crown, there is a small one.

The layer of rock in which this and the University specimen were discovered forms the base of the Laughian series in the Maltese Islands. According to Fuchs,[1] this and the overlying layer, which is an argillaceous variety of the Marl beds, find their analogue in the Horner Schichten of the Vienna basin. It is a reddish-yellow rock of variable character. It averages about twenty feet in thickness, and is remarkably persistent throughout both Malta and Gozo. In organic remains it is one of the most prolific of the divisions of the Globigerina limestones.

The ribs and jaws of *Halitherium*,[2] and the teeth of *Diodon*, *Myliobates*, and *Phoca* are not rare, while most of the mollusca found in the Marls and in the overlying argillaceous or transition bed occur here in profuse abundance.

Pecten Koheni[3] makes its first appearance in this bed. The stratum is bounded above and below by a layer of phosphatized remains of sea life. The upper seam varies in thickness from nine to fifteen inches; the lower seam ranges from an inch to two feet thick. Both seams consist of an aggregation of irregularly shaped nodules, intermixed with which are considerable quantities of the phosphatized remains of molluscs, corallines, echinoderms, crustaceans, fish, and mammals, the whole being firmly bound by an interstitial cement composed of foraminiferal and other calcareous matter. The lower seam is more compact than the upper one, and the line of demarcation between it and the overlying bed is therefore more pronounced. For a distance of several feet below the upper phosphatic layer the phosphatized remains of pteropods and other minute organisms are diffused at irregular intervals throughout the rock.

It was at about this horizon that the Malta University specimen

[1] Fuchs, Th., "Das Alter der Tertiärschichten von Malta," Sitz. d. k.-k. Akad. der Wiss. Wien, Bd. lxx, p. 92.

[2] Adams, Prof. A. L., "On the Discovery of the remains of *Halitherium* in the Miocene Deposits of Malta," Quart. Journ. Geol. Soc. vol. xxii, p. 595, 1866.

[3] *Vide* Fuchs, Th., "Ueber den sogenanten 'Badner Tegel' auf Malta," for description and figure.

was found. The matrix in which the jaw and teeth are embedded has considerable numbers of minute phosphatic nodules distributed through it, and also great numbers of the phosphatized remains of *Hyalæa* and *Vaginella*.

Dr. John Murray considers that this portion of the Globigerina Limestone was deposited on a rising sea-floor, and in, approximately, about 300 fathoms of water.[1]

The late Prof. Leith Adams found several teeth of *Phoca* in the rocks around the Bay of Marsa Forno, Gozo. These he forwarded to the late Professor Sir R. Owen, and on them Owen founded the new species *Phoca rugosidens*. I have carefully gone over the district around Xenchia and Marsa Forno, and have come to the conclusion that Adams' fossils could only have come from the upper layers of the Globigerina bed.

From a comparison of the Malta University specimen and of the isolated tooth found by myself, with those found by Adams and with the description given by Owen, the two former are undoubtedly, I believe, specimens of the extinct species described by Owen under the name of *Phoca rugosidens*. I may note that the late Professor van Beneden, after having seen my sketches, suggested that the specimen might be an example of *P. Scillæ*. I was preparing to send my specimen to him, when I heard of his death. Besides these, numerous canines of a *Phoca* have from time to time been found in the upper Globigerina layers and in the "Greensands." Several very fine examples of these are carefully preserved in the Malta Museum. Remains of fossil seals were discovered in the Malta beds in the early part of the seventeeth century.

Scilla[2] figured some teeth in 1670; and Agassiz and Gervais, commenting on Scilla's illustration, pointed out that it was referable to the genus *Phocodon*.

There is in the Naples Museum a fine specimen which is labelled *Phoca Scillæ*, and which is said to have come from Malta. This specimen has been figured and described by Costa[3] in his appendix to the "Paleontologia del Regno di Napoli." It is much to be regretted that the authorities of the Museum at Naples possess no definite information either as to the locality or the horizon whence it was obtained.

V.—On Scottish Inter-Glacial Deposits.

By Clement Reid, F.L.S., F.G.S.

In the new edition of his "Great Ice Age," Professor James Geikie devotes a good deal of space to the inter-Glacial peats found in Scotland. Perhaps, as the plants from nearly all these deposits have passed through my hands, I may be allowed to venture

[1] Dr. John Murray, "The Maltese Islands, with special reference to their geological structure," Scot. Geograph. Mag. September, 1890.

[2] Scilla, "De Corporibus Marinus," 1670, Roma; "De rana speculazione," 1780.

[3] Costa, O. G., "Paleontologia del Regno di Napoli," part ii, p. 83, Tav. vi, figs. 16, 18.

on a criticism, though I have only had the opportunity of examining two of the localities in the field.

The inter-Glacial date of these masses is accepted by Professor Geikie, and by many other Scottish geologists, and in my notes on the Geological History of the Flora of Britain[1] their view was adopted, though with great hesitation as regards one of the principal localities, a railway-cutting in Cowden Glen, in Renfrewshire. Subsequent work on the abundant material sent by Mr. James Bennie and other observers, and an examination of the Hailes and Redhall quarries, has convinced me that the majority of the plants found in the three most important deposits are of comparatively late date, probably not older than the Neolithic period.

Taking the localities one by one, in the order of their botanical importance, the first place must be given to the section seen in the railway cutting at Cowden Glen ("Great Ice Age," pp. 102–104). This locality I have not examined, so can only speak of the botanical evidence; but it may be remarked that several competent observers have already objected to the acceptation of the peat as inter-Glacial, on the ground that the drift there is constantly slipping down the steep slope, so that the occurrence of Boulder-clay over the peat is insufficient to prove that the peat is the older of the two. When writing my previous paper[2] I remarked that "the plants do not throw any light on the question, for they are all species still living in the district." But since then I have received a larger series of specimens from Mr. Bennie, and among them two seeds of the garden or opium poppy (*Papaver somniferum*). I have not the slightest doubt as to the accuracy of this determination; but it is extremely improbable that such a plant was a native of Britain in inter-Glacial times. The whole assemblage of the plants, and the state of preservation of the animal remains, such as caddis-cases, winter eggs of *Spongilla* and *Cristatella*, and fragments of *Daphnia*, suggest to me an extremely recent date for this deposit.

Next in importance is Hailes Quarry, close to Edinburgh (see "Great Ice Age," p. 99). Here the botanical evidence is somewhat different, for the base of the peaty loam yields a truly Arctic flora, while the higher parts contain only temperate plants. It is possible that the bed with Arctic willows may be inter-Glacial, though I was unable to find any Boulder-clay above it; but as regards the upper portion, the occurrence of charcoal, of seeds of flax, fool's parsley, corn marigold (*Chrysanthemum segetum*), chamomile (*Matricaria inodora*), and hemp-nettle (*Galeopsis Tetrahit*) is against the great antiquity of this deposit.

As regards Redhall Quarry, also close to Edinburgh, the evidence seems even more decidedly to be against the inter-Glacial age of the peat (see "Great Ice Age," pp. 100–101). The section was not clear when I visited it, so I can say nothing as to the stratigraphical evidence, except that the slope of the ground seemed quite sufficient to cause slipping in so unstable a deposit as the Till. The botanical

[1] Annals of Botany, vol. ii, No. vi, August, 1888.
[2] *Op. cit.* p. 183.

evidence, however, is very strong, for the peat yields about fifty plants, including *Fumaria officinalis, Spergula arvensis, Linum perenne* (or *L. usitatissimum*), *Alchemilla arvensis, Carum Carui, Chrysanthemum segetum, Matricaria inodora, Centaurea Cyanus, Sonchus arvensis, Galeopsis Tetrahit,* and *Euphorbia Helioscopia.* These eleven species, and perhaps some of the others, are probably weeds of cultivation. The flax seeds and capsules, judging from the abundance of these remains, may be the refuse of bundles of the cultivated plant put to steep in the marsh. If the seeds belong, on the other hand, to the wild flax, it is strange that they should be so abundant in a peaty deposit, for this plant does not usually grow in marshy places, and is not at the present day found so far north.

The three localities above described are the only ones in Scotland that yield a characteristic temperate flora from beds supposed to be older than part of the Till. There remain, however, several deposits which I am inclined to accept as of inter-Glacial, or perhaps Glacial, date; but these, unfortunately, like all the peaty masses undoubtedly included in the Till, yield nothing but a poverty-stricken, uncharacteristic flora, all the species having an extremely wide range. Kilmaurs, in Ayrshire, where so many remains of the Mammoth have been found, is probably the best known of these localities (see "Great Ice Age," pp. 133, 149, 162). Many seeds were sent to me from this place, but among them there were only six species of flowering plants. Indeed, this poverty of the flora seems to be a common, though not universal, characteristic of deposits in which Mammoth remains are abundant; it was equally marked, for instance, in the Mammoth-bearing loams of Endsleigh Gardens, in London, described by Dr. Hicks.

Another locality where peaty deposits lie unmistakably under Till is at Chapelhall, near Airdrie. This section was first described, many years since, by Sir Archibald Geikie, and on applying to the Geological Survey of Scotland I obtained a box containing several hundred seeds. The result, however, was most disappointing, for they all belonged to two common marsh plants which range throughout the north Temperate and Arctic regions. A further series from other sections at Airdrie yielded about a dozen species, including the dwarf Arctic birch.

In making these comments on the evidence brought forward to prove inter-Glacial periods in Scotland, I do not wish to be misunderstood. I have no objection to recognize such alternations; but for several years I have tried to examine on its own merits the evidence for each supposed inter-Glacial deposit in Britain. In many instances the case completely collapses, but in others it becomes stronger the more closely it is examined. Thus we are gradually bringing to light a definite inter-Glacial period with a characteristic fauna and flora; but before we can pretend to understand the peculiar conditions, it is absolutely necessary to weed out all spurious or doubtful evidence. The case will be enormously weakened in the eyes of all naturalists by the inclusion of such deposits and fossils as those of Cowden Glen, Redhall, and Hailes.

VI.—Can a Diorite become an Acidic Gneiss?

By C. Callaway, D.Sc., M.A., F.G.S.

I HAVE already answered this question in the affirmative in my papers on "Metamorphism in the Malvern Hills,"[1] though I am aware that the assertion has been contested. Nevertheless, the possibility that diorite and quartzite may have a common origin was suggested by Prof. Zirkel as far back as 1876; and in 1892 Mr. W. S. Bayley, of the Geological Survey of Minnesota, distinctly affirmed that a certain quartzite was nothing more or less than "a completely altered gabbro." My conclusion, therefore, is not without support, and, though it has been strongly attacked, it refuses to succumb. I trust I shall be allowed in the present paper to reply to one or two of the objections to it. My remarks refer only to the Malvern area.

So far as I can gather, it has been objected that there is no true passage between the diorite and the gneiss. I have, it is suggested, made an error of observation, and have overlooked breaks in the sections examined. No one has ever pointed out any of these breaks, though I have exhibited series of specimens to the International Geological Congress, to the British Association, and to the Geological Society of London; but I suppose that the belief in the extreme improbability of the alleged change has led to the conclusion that there *must be* error of oversight on my part. It is the old argument of Hume over again—it is easier to believe that Callaway has gone wrong than to believe that a quartzose gneiss should have been formed out of a diorite.

Many mistakes of this kind have no doubt been made. Before the microscope was applied to the study of rocks, they were sometimes almost inevitable. The writer has studied some of them in Anglesey, Caernarvonshire, Donegal, Connemara, and elsewhere. He is therefore fully alive to the risk of error, and has carefully refrained from coming to the conclusion that one rock passes into another until it has been forced upon him by prolonged study in the field and with the microscope.

But perhaps I had better define what is the exact nature of this passage from diorite to gneiss. In the first place, I do *not* mean that there is somewhere a junction between them, at which they are mixed up together in a very intimate manner. Thus, we often find a granite and a grit almost in contact, with the granite passing into an arkose, and the arkose into the grit. Sometimes observers of undoubted competence have described this as a case of a true gradation, and have inferred from it the metamorphic origin of the granite, but no experienced petrologist would make such a mistake now-a-days.

In the next place, I do not intend simply to assert that there is a true passage between the diorite and the gneiss. A mere

[1] Quart. Journ. Geol. Soc., August, 1889, pp. 485, 486; August, 1893, pp. 418–420.

gradation between two kinds of rock proves nothing[1] as to the genetic connection between them. In an igneous magma, for example, one part of a mass may be acidic and the other basic, and they may grade imperceptibly into each other.

What I mean will be best elucidated by an illustration: A piece of beef is roasting before the fire. The central part of the mass is raw and the outer layers are more or less cooked. By cutting into the meat, we see the gradation between the raw and the cooked parts. We also see the cause of the change produced. The proof of the roasting of the meat is therefore complete.

This illustration represents the kind of evidence for the production of acidic gneiss from diorite offered us by the Malvern rocks, and it hardly exaggerates its clearness. We can observe in the rocks the crushing up of the constituents increasing in intensity, and parallel with this change is a mineral transformation. Or the change in the minerals gradually comes in as we approach a plexus of granite-veins. Or both of these causes of alteration may be combined. The evidence of increasing heat as we penetrate a shear-zone is seen in the recementation of minute fragments and shear-lenticles, or in the progressive clearness of the minerals, or in both characters united. Further proof of secondary action is furnished by the relations of the minerals in the completed gneiss, in which we sometimes observe that mica, felspar, and quartz are all moulded upon calcite, which in these rocks is unquestionably a secondary product.

The other objections which have been urged against my conclusions on the origin of the acidic gneiss are chiefly of a chemical nature. The elimination of magnesia and alumina, especially the latter, and the production of biotite out of chlorite, iron-oxide, and potash, are apparently regarded as so improbable that no amount of evidence furnished by field-sections or microscopic slides can establish their reality. This position I contest. I respectfully urge that the chemical theories must give way to the geological facts. If a rock containing 18 per cent. of alumina and 7 per cent. of magnesia has been converted into one in which the percentages are respectively 9 and 0·5, then alumina and magnesia *have* been eliminated. The analyses of Mr. Player prove that the diorite and the acidic gneiss respectively contain the proportions here stated; and, since the one has been changed into the other, we are driven to conclude that the elimination has taken place.

Magnesia and alumina, especially the latter, are no doubt very stubborn things to get rid of; but we have no right to assume that they cannot be eliminated under any circumstances. Laboratory experiments are of very little use to us here. We are quite incapable of determining beforehand what may or may not take place in a granite-diorite shear-zone, where the rock is crushed

[1] Since the above was written, the "Annals of British Geology" for 1893 has appeared, in which the Rev. J. F. Blake (p. xxi) falls into the astonishing error of attributing to me the precisely opposite opinion. It is not surprising that new views should make slow progress when they are thus misunderstood and misrepresented.

into microscopic lenticles, saturated with mineral solutions, and raised sometimes to the point of fusion. If a diorite can be traced without a break into a reconstructed acidic rock, in which the proportions of alumina and magnesia have been reduced, I conceive that we are justified in concluding that, under enormous pressures and at high temperatures, certain chemical changes are brought about which are not produced under ordinary conditions. I do not think I can fairly be called upon to demonstrate the exact mode of operation. It is a step in advance to prove that the thing has been done; *how* it has been done is a further question.

I may point out that there are at Malvern two principal types of gradation between diorite and an acidic gneiss. In the *Ragged Stone Hill* type—(1) the rock has been crushed into a laminated mylonite previous to refusion and reconstruction; (2) the shear-zone contains no granite-veins, though a few felsite-veins are present; and (3) magnesia, but not alumina, has been eliminated, so that the resulting gneiss is highly micaceous. In the *Swingard's Hill* type—(1) the rock becomes progressively sheared towards the fusion-band, and mylonite is not produced; (2) the diorite is interlaced with countless granite-veins; and (3) both magnesia and alumina being eliminated,[1] the result is a quartzose gneiss or gneissoid quartzite.

The diorite of the first type is a granitoid variety (my No. 3); in the second series, it is medium-grained (my No. 1). The chemical composition of both varieties is substantially the same. The difference of behaviour under crushing may have something to do with the greater or less compactness of the rock, the more compact kind more readily slicing into lenticles while shearing. Why alumina is sifted out in the one case and not in the other, there is not sufficient evidence to determine.

I have been quite alive to the alternative view that the diminution in the percentage of alumina may be due, not to the going out of alumina, but to the coming in of silica. If this were admitted, it would not affect the main contention of this paper—that, as a matter of fact, the diorite *does* pass into an acidic gneiss. Furthermore, it would confirm another of my conclusions, that, in the Malvern metamorphism, chemical energy has been exceptionally intense; for this required silica can only have been supplied by the adjacent plutonic rocks.

But the microscopic evidence points to the actual removal of the alumina. If silica had been introduced, it would appear as an intruder amongst crystals of felspar, mica, etc.; but the slides show nothing of the kind. The quartz appears as blebs and granules within the contours of the felspar-crystals. Or it entirely takes the place of the felspar, while the general shape of the crystal is retained, and frequently traces yet remain of a micaceous sheath to the crystals. Or several of the felspars are replaced by silica, and yet scraps of the biotite survive amidst the quartz to outline the position of former felspar-crystals.

[1] In addition, of course, to other bases.

These facts appear to make it highly probable that alumina has been eliminated; but I wish, in concluding, to again point out that the removal of this base is not vital to my general conclusion. I regard it as certain that the diorite has become highly acidic, whether by combined elimination of bases and introduction of silica or by elimination only.

VII.—Peculiar Occurrence of Land and Fresh-water Shells in the Lincolnshire Oolite.

By Beeby Thompson, F.C.S., F.G.S.

(With a page Section.)

In the latter part of 1893 Mr. Albert Wallis, of Brigstock, in Northamptonshire, incidentally told me that he had found some well-known land shells *in* the Lincolnshire Oolite at Brigstock. The section from which these shells came I knew quite well, and Mr. Wallis was well acquainted with recent shells, so it seemed important to ascertain in what manner they found their way into the Oolitic Beds. Having talked the matter over with my friend Mr. Lionel E. Adams (Treasurer of the Conchological Society of Great Britain), we decided to go over to Brigstock, and examine the section and the shells, and arrive, if possible, at some explanation of their peculiar position. Accordingly, on June 16 of last year, we met Mr. Wallis there for the purpose indicated.

The district in which Brigstock is situated has been described by Prof. Judd[1]; but in his Memoir two different sections are referred to as at Brigstock Mill (see pp. 101, 149, and 191). That described on page 149 is the one that we are concerned with, and is the one to which the term Brigstock Mill most appropriately belongs, for it is quite close to an old windmill, on the road towards Stanion, *i.e.* on the north-west of Brigstock, and about a mile, or less, from the village.

The section Prof. Judd describes on pp. 101 and 191 of his "Geology of Rutland," Lord Lyveden's pits, I find was commonly known as the "brick-kilns," and is not now open; it was situated on the north side of the road just about half way between Brigstock and Stanion.

Description of Inferior Oolite Section at Brigstock Mill.

1. The upper part of the section consists of soil, Boulder-clay, and gravel. The Boulder-clay is scarcely distinguishable from the soil above, except perhaps that it is a little redder and stiffer; but both contain very numerous pebbles and fragments of flint and chalk, such as are usually found in the "drift" of the district. In places the stones are so numerous as to almost constitute a gravel.

2. Under the above, for a variable distance vertically, everything is very confused—Boulder-clay, stones, fine sand, and shelly oolite being very much mixed up, and consequently the junction with the true Oolitic Beds below is very irregular. The thickness of this part

[1] "The Geology of Rutland," etc., by John W. Judd. Memoirs of the Geological Survey, 1875.

Shells.
July 14/94.

\+ Places where recent shells have been found.

Shells found 9 feet to the right, in a face nearly at right angles to this section.

Scale: 6 feet to the inch. Length of section 36 feet.

a, *a*. Soil to brown drift, with few stones and boulders.
b, *b*. Brown clayey drift, with many boulders (oolitic, and flint, and chalk predominating), Boulder-clay.
c, *c*. Sandy clay in bands without boulders; probably disturbed Upper Estuarine clay.
d. Distorted Oolite and Boulder-clay, much confused.
e. Redistributed Oolite in small stratified beds, with flint and oolitic water-worn stones and recent shells + often distorted.
f. Disintegrated Oolite with large lumps of hard oolitic rock.
g. Floor of quarry.

Section of Lincolnshire Oolite and Drift at Brigstock, showing positions in which Land and Fresh-water shells were found by Mr. Albert Wallis.

may be three or four feet; but it thins out considerably towards the adjacent road.

3. The Lincolnshire Oolite here belongs to the so-called "shelly facies" (Judd), that is, it consists almost wholly of small shells or fragments of shells, mostly water-worn, or encrusted with carbonate of lime, so that all trace of the finer ornamentation is lost, together with concretions not obviously connected with the shelly character. Gasteropods are more numerous than any other form of fossil.

[At some places in the neighbourhood the fossils of this "shelly facies" of the Lincolnshire Oolite are better preserved, and it was from such, near to Weldon, that so many of the forms recently described by Mr. Hudleston, in his Monograph on the Inferior Oolite Gasteropoda, came.]

The upper portion of the Oolite is soft and sandy-looking, and can be picked out quite easily with a knife. The lower portion is mostly harder, more compact, and even somewhat crystalline; and nodular or hummocky masses of this rise, in places, into the softer zone above. The entire thickness exposed is as variable as the clay and soil, etc., resting on it, but in the deepest part reaches nine or ten feet.

4. Here and there in the section are gullies, or "pipes," filled in with Boulder-clay or gravel; they begin in the confused layers (2), and mostly reach below the present working.

The page section illustrating this paper has been produced from a coloured diagram kindly made for me by Mr. Wallis last summer, 1894, and is a record of his personal observations.

The section is really worked as a gravel-pit, and the finer oolitic material, when screened, appears to be very good for garden paths and such like purposes. It appears that the villagers have a right to the gravel, whereas the soil above is private property, and so things are in a peculiar position, and the privilege of digging gravel is greatly curtailed.

The recent shells that have been found at Brigstock all occurred *in* the limestone, at four or five different places, some distance apart horizontally, and at variable depths. The first and chief find was at a spot, now enclosed and covered in by a hen-shed, some ten feet below the surface of the ground, and seven feet below the upper surface of the limestone. Here the shells occurred in a little patch of clay, quite unconnected with the surface or the Boulder-clay, so far as could be ascertained; that is, they were not found in or near to one of the "pipes" previously referred to.

The shells that have been found are, or were at first, fairly perfect, although extremely fragile, and bleached. They include the following species:—

Succinea putris.	*Helix nemoralis* or *arbustorum*?
Cochlicopa lubrica.	*Pupa marginata.*
Helix pulchella.	*Pisidium pusillum.*

The shells were named by Mr. Lionel E. Adams, but one or two were submitted to Mr. J. W. Taylor, of Leeds, for confirmation.

Next come the interesting questions of how and when these shells got embedded in the limestone. To the question how? we can give a fairly definite answer. The upper part of the Lincolnshire Oolite, for at least as far down as these shells were found, must have been disturbed and re-deposited by water, or ice and water, and the shells introduced at this time; for although they have been found at four or five places, in none of these was there any crack or pipe leading to the surface, through which they could have made their way down, even supposing such fragile shells could have survived the journey.

The "pipes" or gullies containing clay and stones have been particularly searched for these shells, but without reward; this is not surprising, for the "pipes" are not wide enough (they vary from a few inches to a foot at the most) for the matter in them to have been precipitated down in mass, even supposing they were at any time open tubes or crevices. Besides, it is pretty certain that these "pipes" were slowly made and enlarged by water percolating from the surface to the springs at the base of the Oolitic series, so that all the material now filling them has gradually got in and worked itself down. Nearly all the flatter stones in them are on edge, a position they would naturally assume in making their way down in the manner indicated, because it is the one offering least resistance to their passage.

It is unlikely that fragile shells could have survived the protracted journey involved by this explanation, even if introduced at any period, at the top, enclosed in a matrix of clay or soil. It is almost certain, however, that the "pipes" are much newer than the period of the introduction of the shells into the limestone (see below).

Having arrived at the conclusion that a re-deposition of the Oolitic Beds, as far down as the shells were found, was a necessary corollary to their being so found, a particular search was made for other evidences of it, and we found, without difficulty, here and there in the Oolite, *about as low down as the shells were found, but no lower*, pebbles and small pieces of flint similar to those found in the "drift" above. Very likely the hummocky masses of indurated limestone previously referred to (3) indicate, where they occur, the depth to which the disturbance which permitted of the introduction of the shells extended.

The question of when? this re-deposition occurred is a more difficult problem to solve. I can find no record of the occurrence of these land and fresh-water shells in any of the Glacial deposits, yet it would appear that they cannot be more recent than the Glacial period. I would offer the following hypothesis on the subject: The animals that formerly inhabited these shells lived in the district near to where they are now found prior to the Glacial period, and their habitations got gradually buried in the soil or clayey subsoil; from this position they were moved with masses of the underlying rock by the advancing ice, and mixed with material from other districts, thus forming the oldest Glacial deposits of the district, of which scarcely a trace in its original form now exists. During the

period known as "Inter-Glacial" the melting of the ice produced strong currents of water which washed away most of the argillaceous matter of this early Boulder-clay, leaving only the coarser material, such as sand and gravel, and even baring and disturbing the underlying rock, and re-depositing its material. It is not impossible for the shells we are considering to have been preserved during all this time, if surrounded by a matrix of clay, for beautifully preserved fossils (derived) are often found in the Boulder-clay, and I have even found them in the gravels below, though rarely.

The disturbance and re-deposition of the Lincolnshire Oolite present no difficulties, for there are other instances of re-deposited beds. A considerable area, not far from Northampton, is covered by re-deposited and finely-washed Northampton sand, and this has Boulder-clay above it, and so is older than the latter.

I have carefully examined a very similar section to the one referred to in this paper, situated at Little Oakley (see Judd's "Geology of Rutland," p. 191), and so has Mr. Wallis, but there was no evidence of re-deposition, and no shells could be found. At this place a stream enters the pit from below the Oolitic Beds and passes out under the same, and no doubt discharges into the Harper Brook not far away.

I may say, in conclusion, that a fluviatile origin for the shells was considered, and regarded as untenable.

VIII.—On a Sandy Ironstone occurring above the Chalk at Capel, near Dover.

By Frank Rutley, F.G.S.;
Lecturer on Mineralogy at the Royal College of Science, London.

BETWEEN Dover and Folkestone there are certain deposits of ferruginous sandstone or sandy ironstone, well known to geologists, and somewhat doubtfully referred to some portion of the crag. They may be the equivalents of the Lenham Beds, which are assumed to be the lower part of the Coralline crag, and which have been correlated with the Diestian Beds of Belgium. This view is entertained by Prof. Prestwich, Mr. Clement Reid, and others, and is based upon palæontological evidence (chiefly from Lenham, near Maidstone), from which locality Mr. Reid procured casts of the following fossils:[1]

Ficula (Pyrula) reticulata	*Pectunculus glycimeris*
Ringicula ventricosa	*Diplodonta rotundata*
Turritella incrassata	*Terebratula grandis*, etc.

On the other hand, some geologists, including the late Mr. H. W. Bristow, Mr. W. Whitaker, and the late Mr. W. Topley, have been inclined to regard these deposits as coeval with the Lower London Tertiary and possibly as equivalents of the Oldhaven or Woolwich Beds.

Be this as it may, no one yet appears to have inquired into the microscopic character of these highly ferruginous deposits.

A section made from a specimen of sandy ironstone, which I

[1] The Pliocene Deposits of Britain, 1890, p. 42.

collected years ago at Capel, near Dover, shows, under the microscope, that it is composed almost exclusively of quartz-sand and limonite. The latter substance, which appears of a deep brownish-red colour in reflected light, does not exhibit any pisolitic or other structure, but is simply an amorphous cement which holds together numbers of minute grains of quartz-sand, some of which are rounded, while a large proportion of them are sharply angular. Here and there a small grain of felspar, of somewhat turbid aspect, shows in convergent light a dark brush or the cross of a bisectrix, which separates into dark brushes on rotation, but such grains are of comparatively rare occurrence, and the sand of the deposit may, therefore, be regarded as an almost pure quartz-sand. In these grains fluid lacunæ, containing bubbles, may be detected under high powers, and occasionally small rod-like crystals may be seen as inclusions in a quartz-grain. These appear in many cases to be rutile.

The question naturally arises whence this fine quartz-sand came. We meet with none of the grains which are composite in character, that is to say, there are no fragments composed of agglutinated grains such as one would expect to meet with if the material had resulted from the *immediate* disintegration of a quartzite or schist, neither are these grains composed of two or three adherent crystals of different minerals such as would come from the immediate disintegration of a granite or other eruptive rock. The fact that there is comparatively little attrition involved in the transport by water of such minute grains would sufficiently account for the sharply angular character of a large proportion of them. There is, consequently, nothing to prove that they may not have travelled a long distance. That they were originally derived from the disintegration of eruptive rocks is tolerably certain, but it is more than probable that such material subsequently entered into the composition of some sedimentary rock, a sandstone, or a quartzite, and that it is from the disintegration of some such rock that the sand in question has been more immediately derived.

According to Dr. Sorby, about one-third of the grains constituting the Hastings Sand, at Hastings, are rounded by attrition.[1] This seems to be about the proportion of rounded grains in the sand of the ironstone we are now considering, and it does not appear by any means improbable that these sand-grains may have been derived either from the detritus of certain beds in the Greensand of the South-eastern Counties, in which Dr. Sorby detected an average of from $\frac{1}{2}$ to $\frac{1}{3}$ of rounded grains, or from the Hastings Sand. The denudation of the Weald would have provided vast quantities of such material, and Prof. Prestwich considers "that the anticlinal arch over the Wealden area had been formed and the Chalk greatly eroded, so that in some places the Greensands below the Chalk had been laid bare, before even the lowest of the Eocene beds was deposited."[2] It, therefore, appears highly probable that the sands

[1] Anniversary Address, Geol. Soc. Lond. 1880, p. 34.

[2] Jukes' "School Manual of Geology," 4th edition, edited by A. J. Jukes-Browne, p. 334.

resting on the Chalk at Capel, Lenham, and elsewhere in Kent, have been derived from detritus supplied by the denudation of Neocomian strata.

On the other hand, that sands such as these might have been directly derived from the disintegration of granitic rocks, is not impossible. Speaking of the quartz-grains derived from quartzose felsite, Dr. Sorby says: "But very often there is a remarkable rounding of the angles, which might easily lead anyone to think that they were water-worn. Even the grains of quartz derived from granite sometimes show this character to a less extent, but the rounding is usually accompanied by small surface ridges, which clearly show that their rounded form was not due to mechanical wearing." [1] This phenomenon is the result of corrosion of the surfaces of the quartz-grains by alkaline solutions formed by the decomposition of the felspathic constituents of the rock, and it therefore remains to be decided whether the sand grains in our ironstone were rounded by corrosion or by attrition. If the former, then we may assume that the sand has been immediately derived from some granitic rock; but where it came from is a difficult question to answer. If from any great distance, the material might have been ice-borne, but this is pure speculation; and from the absence of grains composed of several adherent crystals or grains of different mineral constitution, I am inclined to favour the view that such rounding as these grains present is due to attrition, and that they have been derived from sandstones, probably of Neocomian age. Under what conditions they were deposited in post-Cretaceous times I venture to express no definite opinion; but it seems hardly probable that the cementing process took place under the pressure of any appreciable thickness of superincumbent rock, since the quartz-grains are more or less widely separated by the cementing material, a circumstance which would seem to indicate that the sands were subjected to little or no pressure from overlying deposits, and consequently that the ferruginous matter of the cement was not infiltered from superjacent strata. That the deposit is not lacustrine seems sufficiently proved by the fossils which have been found in it.

IX.—The Tower of Eccles-by-the-Sea.

By Rev. E. Hill, F.G.S.

THE church-tower of Eccles-by-the-Sea, on the coast of Norfolk, once buried in the moving sand-dunes, has been rendered classical by Lyell through his description of it in his "Principles." Such a monument should surely not be allowed to pass away without an obituary notice.

Lyell gives drawings of its appearance in 1839 and in 1862. In April 1893 Professor Bonney and I, while at Cromer, paid a visit to it, making measurements and sketches. The foot of the tower was then about thirty yards from a neap-tide high-water mark, and its level scarce four feet above: spring-tides must have nearly or

[1] *Op. cit.* pp. 21, 22.

quite reached it. After our visit a gale, in November 1893, bared the foundations of the church: plans were made, which have been preserved. On Wednesday, January 23rd, 1895, a storm arose, described by a resident as beyond anything he had seen. At six p.m. the waves were breaking furiously against the tower and their spray was flying over its summit. At seven it had fallen.

The line of sand-hills forms a defence against the sea for a level tract of cultivated country behind. My sketch indicates a breadth of about twenty yards for this rampart and a height of some twenty or thirty feet. An account says that "the havoc to the sand-banks baffles description . . . . they are not half their original size in breadth and height . . . . the sea overflowed the gap-way and the manor house was in danger of being inundated . . . . Eccles has had a very narrow escape of the catastrophe which happened in 1605, when hundreds of acres of land, with sixty-six houses and their inhabitants, were swept away in one night."

Lyell adduces this ancient ruin among his evidences of the encroachment of the sea on the eastern coasts of England. His figures appear faithful, for the appearance and dimensions of the sand-dunes at our visit were just the same as in them. The figure of 1839 shows the tower emerging from the very centre of the line of sand-hills. That of 1862 shows it nearly free of them on their seaward face, at a distance from their centre about equal to its own height. As its height was about forty feet this might indicate that the sand-hills had travelled inland about forty feet in twenty-three years. At our visit in 1893 we found the line of dunes entirely separated from the tower, and we measured its distance from their centre as about thirty yards, which gives an advance of ninety feet in fifty-four years. Lyell alludes to the possibility of a subsidence in the coast, but this is not required to explain the march of the sand-dunes.

I have to thank Professor Bonney for the loan of his notes, and the Rev. J. S. Whitney for an answer to enquiries, and for an extract from the "Eastern Daily Press" of January 26th, 1895, containing an account of the event.

X.—On the Genus *Plutonides* (non *Plutonia*) from the Cambrian Rocks of St. David's.

By Henry Hicks, M.D., F.R.S., F.G.S.

QUITE recently, Mr. B. B. Woodward, F.G.S., of the British Museum (Natural History), called my attention, for the first time, to the fact that the name *Plutonia*, which I adopted for a genus of Trilobites in 1868, had previously been used by Stabile (Atti. Soc. Ital. Sci. Nat. vii, p. 121, 1864) for a genus of Mollusca. As Stabile's generic term has therefore a priority of four years it is necessary that I should rename the Trilobite, and it has been suggested to me by Mr. Belinfante, B.Sc., Assist. Sec. Geol. Soc., that *Plutonides* would be the most suitable term and the one least likely to lead to confusion. In the Report of the British Association for 1868, p. 69, where the genus is first mentioned, after describing

the beds in which it occurs I refer to it as follows: "The new genus, for which the author proposes the name *Plutonia*, is only known to occur in these beds. This remarkable fossil is of very large size, equalling, indeed, in this respect *Paradoxides Davidis*. It is, perhaps, also more nearly allied to the genus *Paradoxides* than to any other known, but its peculiar character of being covered all over with very strong tubercles, associated with an unusual position for the eye suture, and straight, very long thoracic pleuræ, is sufficient to stamp it a new and distinct genus."

It was more fully described by me afterwards in the Quart. Journ. Geol. Soc. vol. xxvii, p. 399, as *Plutonia Sedgwickii*. One species only has been discovered and no complete specimen. As mentioned above it resembles, in some particulars, the genus *Paradoxides*; but I know of no species in that genus which has such wide pluræ, or such a pronounced ornamentation on all parts of the body. The pygidium has not been found; but some fragments which have turned up seem to indicate that it approached more nearly that of *Anopolenus* than to *Paradoxides*. *Plutonides* greatly exceeded in size any specimens of *Anopolenus* yet discovered, as portions of the body, which I obtained, show that it could not have been less than seven inches across at its greatest width, or one inch wider than the largest *Paradoxides* found by us at St. David's, now in the Museum of the Geological Society. Its length, however, would evidently be less than *Paradoxides*, with fewer segments to the thorax.

REVIEWS.

I. — Collected Papers on some Controverted Questions of Geology. By Joseph Prestwich, D.C.L. (Oxon), F.R.S., F.G.S. (London: Macmillan & Co., 1895. 8vo, pp. xii and 280.)

THE book before us consists of a series of articles, the subjects of which have occupied the author's attention during many years, and concerning some, if not all, of which he is more or less at issue with many of his fellow-geologists. "With respect to the main facts of geology," says Professor Prestwich, "we geologists are in general of one opinion, but with respect to the explanation of many of those facts, we hold very divergent opinions."

Article 1 treats of "The Position of Geology," and is directed against the prevailing school of geologists in this country who hold the doctrine of Uniformity—uniformity of action both in *kind and in degree* throughout all geological time; and the Continental school who hold uniformity in *kind or law*, but not *uniformity in degree*.

The points touched upon embrace the rate of sedimentation, calculated upon the transporting power of rivers, which are estimated to lower the level of the land one foot in 6000 years, or one thousand feet in 6,000,000 years. The author remarks that the rate might be doubled if the calcareous matters held in solution, as well as the matter held in suspension, were taken into account. Professor Prestwich also objects to a *mean rate* of elevation of land at 2½ feet

in a century taken from the coast of Norway, when at the North Cape it is as much as five feet in a century.

He refers to the vast antiquity of man, based on his contemporaneity with the extinct mammalia and the recurrence of Glacial periods, but whilst he condemns the needless demands of glacialists who fix the disappearance of Palæolithic man and the Quaternary fauna at 80,000 years back, he states that it is possible, on other grounds, that the antiquity of man will have to be carried back further into the Glacial period (see footnote, p. 8).

Other estimates of time are based on the Westleton marine shingle-bed, Bucks, at 600 feet above O.D., and the same bed in Suffolk occurring at sea-level; on the Moel Tryfaen shell-bed at 1400 feet elevation, estimated at 88,000 years; and the raised beaches of Norway 200 to 600 feet, assumed to be from 8000 to 24,000 years old. From the Westleton bed he argues that the time-estimates, based on the other raised beds, are worthless, in which we cordially agree.

Professor Prestwich then protests against those physicists who maintain the theory of a rigid crust, and cites the modern raised beaches, etc., as evidence in refutation of such a view. He also doubts the assumption of a solid crust of 800 to 2500 miles in thickness, and prefers to leave it an open question, and suggests that it is probably not more than 20 to 30 miles thick.

Article 2 is devoted to "Considerations on the date, duration, and conditions of the Glacial Period, with reference to the Antiquity of Man." Here the author makes use of the data regarding modern glaciers and other evidence to show that the enormous periods of time required by Croll's theory are uncalled for, and the evidence for successive Glacial epochs unsatisfactory.

Professor Prestwich's next essay is "On the primitive characters of the Flint Implements of the Chalk-plateau of Kent, with reference to the question of age and make." This article is illustrated by twelve plates of worked flints, showing the various characteristic forms that are relied upon by the author to establish the presence of man antecedent to the time when these implementiferous flint-gravels were formed, and long antecedent to that when the present valley-system had been excavated.

The fourth article, "On the Agency of Water in Volcanic Eruptions, and on the primary cause of Volcanic Action" (illustrated by plate xiii), is followed by one "On the thickness and mobility of the Earth's Crust from the geological standpoint"; the sixth and last being "On Underground Temperatures—with observations on certain causes which influence the conductivity of rocks; on the thermal effects of saturation and imbibition; and on a source of heat in mountain-ranges, as affecting some underground temperatures."[1]

[1] It may interest some of our readers to know where these articles first appeared. Art. 1 appeared in the "Nineteenth Century" for October, 1893, p. 551. Art. 2, in the Quart: Journ. Geol. Soc. August, 1887, vol. xliii, p. 393. Art. 3, in the "Journ. Anthrop. Inst." for 1892, p. 246. Art. 4, Proc. Roy. Soc. April, 1885, p. 117. Art. 5, *ibid.* April, 1888, p. 156. Art. 6, *ibid.* 1885, p. 1.

The six articles make a very useful and readable volume, which every geologist should possess. They are full of valuable facts and suggestions, and are the result of long years of patient and careful observations and study by one of the most able geologists of this century; and, although we may not agree with the author in all his views, we cannot but feel interested in the subjects he so ably lays before us.

II.—The Fossil Insects of the Primary Periods. By Dr. Charles Brongniart, of the Natural History Museum, Paris. (Recherches pour servir à l'histoire des Insectes Fossiles des Temps Primaires). St. Etienne, 1894.[1]

THIS valuable monograph is the result of sixteen years' continuous devotion on the part of the author to the study of that remarkable Palæozoic insect fauna, so wonderfully preserved in the fine Coal-shales of the Commentry Collieries, situated in the Department of the Allier, Central France.

Some fifty or sixty years ago the acknowledged rarity of fossil insects in strata older than the Wealden or Lias, and their unrecorded existence in Palæozoic rocks, naturally led to false assumptions to account for their absence; climatic conditions being alleged as noxious and unfavourable to air-breathing animals. Since that period, however, isolated discoveries in the Coal-measures of England, Germany, and America have shown how unsafe it is to generalize from negative evidence in speculations of this kind.

It has been reserved to one favoured locality in a circumscribed area of Central France to furnish more specimens of fossil insects and in a better and more complete condition than in all the previously known localities of the world put together, thus showing that insects were abundant, as might have been anticipated from the rich forest growth of the period, and that the existence of insect feeders as Spiders, Scorpions, and insectivorous forms of Reptilia might also have been prognosticated.

The discoveries at Commentry are entirely due to M. Henry Fayol, the Engineer and General Manager of the Commentry Coal-pits, whose enlightened zeal and careful attention to the fossil contents of the strata in the works under his charge have yielded such ample reward.

One group of these fossil insects, the largest in point of number of individuals, the family of Blattidæ or Cockroaches, is only outlined in its principal genera in the present work, Dr. Brongniart reserving them for a special and more exhaustive study in a future contribution.

The monograph is divided into three parts, to which is added an atlas of plates forming a separate volume.

The first part gives an historical account of the works which have been already published on fossil insects, followed by a bibliographical

[1] This work forms the thesis presented by M. Brongniart to the Faculty of Sciences, Paris, to obtain the grade of Docteur ès Sciences Naturelles, which has been recently awarded him.

index of authors and references brought up to date, an extremely valuable list, for much of which the author is indebted to Professor Scudder's Bibliography of Fossil Insects (1882).

The second part consists of a study or investigation of the neuration of the wings of *living* insects, belonging to the orders Neuroptera, Orthoptera, and Fulgorida, groups to which the Palæozoic types seem to be most nearly allied.

This portion of the work the author has felt compelled to undertake for the more intelligible comparison of fossil forms with their living representatives. The variety of names given by different authors to the nervures and other critical parts of the wing structure has caused much confusion. The importance of a clear and distinctive nomenclature of the plan of neuration will be recognized by entomologists, as the classification of fossil insects mainly rests upon the position and distribution of the nervures or veins of the wings, which are too often the only parts preserved.

M. Brongniart remarks on this portion of his work that "we have now, thanks to this study of the neuration, a foundation on which to attempt the description of fossil species, not only of the Coal-measures, but also of all geological epochs. Naturalists who devote themselves to the study of fossil insects will be able to resort with profit to our illustrations, and to our text to establish comparisons."

The third part of the monograph deals with the specific object of the work,—the Comparative Study of the Fossil Insects of the Carboniferous rocks with living types, by the light of the numerous examples found at Commentry, many of which have been so marvellously preserved that we have not only the wings but also different parts of the body to assist in identification.

Mr. S. H. Scudder, the eminent American entomologist, who has written so much on fossil insects, in his memoir on the "Affinities and Classification of Palæozoic Hexapoda,"[1] unites all the Coal-measure insects in one great division, under the name of Palæodictyoptera (a term previously employed by Goldenberg), as he considers they all belong to extinct species and are exclusively developed in Palæozoic deposits.

Dr. Brongniart, on the contrary, does not agree with this opinion, which he regards as a too hasty conclusion from insufficient and fragmentary materials, and says "that Mr. Scudder, in establishing this classification, had not at his command specimens so well preserved and so numerous as mine, and that by the study of the insects of Commentry we are able to demonstrate that the Palæozoic types can be classified in the orders created for living species."

Dr. Brongniart recognizes three orders: the Neuroptera pseudo-Orthoptera, the Orthoptera, and the Homoptera, in a group having affinities with the Fulgorida.

The order Neuroptera, the author says, "is largely represented and already affords at this remote epoch a great variety of forms. Some species are of gigantic size, and at all events it is well to

[1] Memoirs of the Boston Society of Natural History, vol. iii, No. xi, 1885.

bear in mind, that nearly all these insects surpass in size their living representatives." Several families are included in this order, among which are the Protephemerida, whose neuration recalls that of the living Ephemerida (May-flies), of which they may be considered the precursors; and the Platypterida, of which the genus *Lamproptilia* contains two species of large size, whose span of wing attained some seven to eight inches, and what is also remarkable, the wings bear evidence of having been richly coloured and ornamented by rounded spots.

The family Protodonata comprises species which may be considered as the predecessors or ancestors of living Libellulæ (Dragon-flies). These ancient types were often of gigantic size; one species, of which we have a superb restoration figured in the atlas, measured about 70 centimetres or 28 inches in the spread of wing, giving one a lively idea of these aerial giants of other days.

The family Protoperlida resembles the actual Perlida, whose larval state is passed in the water, and while in that condition their food is the larvæ of May-flies and other insects. All the foregoing are insects with incomplete metamorphoses and whose larvæ live in the water.

In the order Orthoptera Dr. Brongniart has placed all those fossil insects which resemble living species of the order. Thus, among the Carboniferous insects he identifies species which can be approximated to several existing families, such as the Blattidæ, the Locustidæ, the Acrididæ, and the Phasmidæ.

That these early precursors of the Blattidæ, our familiar Cock-roaches, were a numerous and widely distributed family in the forests of the Carboniferous epoch may be predicated from the fact of their remains having been found in most of the European and American Coal-fields; but in no locality have they been met with in the same abundance and perfection as at Commentry, where nearly a thousand specimens have been collected by M. Fayol.

The Protolocustidæ, of which numerous remains have been found, appear to have so close a relationship to our living Locusts or Grass-hoppers, not only in the form and neuration of the wings but also in the characters of other parts of the body, that they seem, in M. Brongniart's opinion, scarcely to have required being placed in a distinct family.

The Acrididæ or Cricket family was also represented by numerous individuals, two genera of which have been distinguished.

Coming to the last order discussed by the author, the Homoptera, of which there are but few representatives at Commentry, and these differing in several characters from existing types, have been referred to the group Fulgorina.

It will be noted that in this summary of the fossil insects of the Carboniferous rocks, no mention has been made of the Coleoptera or Beetles, although certain insect borings found in fossilized wood have been ascribed to them. Had, however, beetles existed at this remote epoch, it would be natural to expect other authentic indications of their presence than mere borings; such, for example,

as the hard wing-cases or elytra, which are by no means rare among the insect remains of the later Mesozoic period. These curious and interesting borings have not only been found in the silicified fossil wood of the French Coal-field of the Loire but they also occur in the calcareous nodules, containing plant-remains, of the Lower Coal-measures at Oldham, near Manchester. Although these perforations simulate similar destructive operations of actual wood-boring beetles, it would be an unsafe conclusion, without further evidence, to pronounce them to be their work, as they may be due to a burrowing larva of some other and as yet unknown insect.

As might be expected, we have no traces in the Palæozoic rocks of the higher orders of insects, such as the Lepidoptera and Hymenoptera (Butterflies and Bees).

The atlas of 37 plates accompanying the text will be regarded with especial pleasure, not only for the intrinsic interest of the fossils delineated but for the beauty and clearness of execution of the figures. The first 12 plates are devoted to the figures of the neuration of living insects to serve as terms of comparison with fossil types. These drawings have been made by the aid of the *camera lucida* from nature by M. Brongniart and reproduced directly by the heliogravure process. The remaining 25 plates are occupied with the figures of the fossil insects of Commentry, the drawings of which are mostly of natural size and of scrupulous fidelity, due to the extreme care and labour expended on them by the author. Some of the figures are photographed directly from the specimens themselves and reproduced in heliogravure.

It is a fact worthy of record and an example to be encouraged, to note that this work, which appeals perhaps but to the few, and whose author could not hope for material gain by its publication, has been printed at the cost of "La Société de l'Industrie Minérale de Saint Etienne," to whose wise and generous use of the funds at its disposal the scientific public is indebted for a valuable accession to palæontological literature.

The examination of this abundant insect fauna of Commentry, so well depicted in the specimens figured in the atlas, will doubtless claim the notice of entomologists and palæontologists as to the immense antiquity of the class Insecta. Not only do the great variety, perfection, and size of the specimens cause astonishment, but their close resemblance in many instances to living forms arrests attention.

MARK STIRRUP.

III.—ANNALS OF BRITISH GEOLOGY, 1893. A Digest of the Books and Papers published during the year; with an Introductory Review. By J. F. BLAKE, M.A., F.G.S. 8vo, pp. xxiv, 365; with 90 Illustrations. (London: Dulau & Co., 1895.)

ONCE again Professor Blake's welcome volume makes its appearance. This time we are glad to note its originator speaks more hopefully of the future, and we earnestly trust it may become a "hardy annual." The conditions are that it shall receive continued and steady support; and by British geologists, at least,

this will surely not now be withheld, seeing its great utility, which each succeeding year of publication enhances.

The present issue is conducted on the same lines as the last, "with the exception of the greater brevity of the notices of publications of a text-book nature"; a wise improvement, and we only wish Prof. Blake could be also induced to forego the section "Foreign Geology (published in Britain)," for reasons explained on previous occasions.

The book is a wonderful piece of work, and a monument of patient industry (730 papers read and abstracted!), and though we sympathize in his resentment at its being called "a compilation," we think Prof. Blake does himself injustice when he says "it is as pure a piece of original research as I have ever been guilty of"; surely he does not wish it to be inferred that, to take a single example, his monograph on the Corallian Rocks of England was nothing more than a digested abstract of the work of others? Slips there are undoubtedly in places, but how can such be avoided in a work of this description? Gratitude for its production would blind all but the most captious reviewer to far more serious defects.

The heartiest thanks of all geologists should be Prof. Blake's.

REPORTS AND PROCEEDINGS.

Geological Society of London.

March 20th, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On Fluvio-Glacial and Interglacial Deposits in Switzerland." By C. S. Du Riche Preller, M.A., Ph.D., F.G.S., F.C.S., A.M.I.C.E., M.I.E.E.

This paper is the outcome of one published in the Geological Magazine of January 1894, on the "Three Glaciations in Switzerland," in which the author described various glacial deposits near the lake of Zürich. He now describes a series of fluvio-glacial conglomerates and interglacial lignite deposits near the lakes of Zürich, Constance, Zug, and Thun, which, together with analogous deposits at the base of the Eastern, Western, and Southern Alps, constitute further evidence of two inter-Glacial periods, and therefore of three general glaciations, the oldest of these being of Upper Pliocene, and the others of Middle and Upper Pleistocene age respectively. As regards the origin, age, and the time required for the formation of several of the Swiss deposits referred to in the paper, the author arrives in several respects at conclusions differing from those recently enunciated by others. The author also argues that the first inter-Glacial period was probably of shorter duration than the second; and in confirming his former conclusion that every general glaciation marks a period of filling-up, and every inter-Glacial period marks a period of erosion of valleys, he avers that, if this conclusion be correct, it must needs be destructive of the theory of glacial erosion.

2. "The Bajocian of the Mid-Cotteswolds." By S. S. Buckman, Esq., F.G.S.

The Mid-Cotteswolds is defined as the district between the valleys of the Frome and the Chelt. A description of twenty-five sections is given, dealing principally with the strata found between the Upper *Trigonia*-grit and the upper Freestone—such strata being called, for the purpose of present distinction, "the intervening beds." Of these twenty-five sections, seventeen, lying between Stroud and Leckhampton, are discussed in Part I of the paper to show the succession of the intervening beds, to point out that Cotteswold geologists have confounded two distinct deposits, the Lower *Trigonia*- and Gryphite-grits, to prove that the former, and not the latter, is the more persistent stratum, and to give evidence that denudation, called "Bajocian denudation," has, prior to the deposition of the Upper *Trigonia*-grit, cut right through the intervening beds in the neighbourhood of Birdlip, so as to make a shelving trough six miles wide and about thirty feet deep.

The remaining eight sections are described in Part II of the paper. They lie eastwards of Leckhampton, and are given to show the discovery of another ammonitiferous horizon in the Cotteswolds, yielding angustumbilicate *Witchelliæ*. It is proved that this bed is above the Notgrove Freestone and below the Upper *Trigonia*-grit; so that it is really an addition to the stratigraphical sequence hitherto recognized in the Cotteswolds. Its ammonites show it to have been deposited contemporaneously with the middle of the Sandford Lane Fossil Bed, and yet it is removed by ten to twelve feet from the Gryphite-grit=lower part of that bed. In the Mid-Cotteswolds this important *Witchellia*-bearing bed is only preserved over an area of about $1\frac{1}{2}$ square miles, because it has been mainly removed by Bajocian denudation; and only one side of one small quarry yields a favourable exposure. No other locality showing this deposit has yet been found in the county.

Two plotted diagrams are given to show the developments of the beds in the different sections, and to illustrate the result of the Bajocian denudation. In an Appendix to Parts I and II various notes are given, and attention is called to a remarkable oyster as a document of historic value evidencing the Bajocian denudation.

Part III of the paper gives the chronological sequence of Brachiopoda in Dorset and the Cotteswolds in the Inferior Oolite, to show their value for purposes of exact correlation when ammonites are absent; and to illustrate that the Brachiopods are a good medium of exchange in regard to the strata of the Cotteswold and Dorset districts respectively, that in some cases they are such in regard to the two districts, and in other cases they fail in this respect, so that ammonites become the only true medium of exchange between the beds of different basins.

An Appendix to Part III describes certain new species of Brachiopoda, and gives notes upon others.

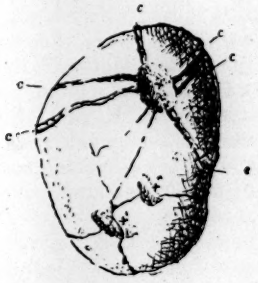
CORRESPONDENCE.

THE INDENTATION OF THE BUNTER PEBBLES.

Sir,—In "Annals of British Geology," 1892, p. 52, is a review or abstract of a paper entitled "The Trias of Cannock Chase," by T. M. Reade. In this abstract we read, "The indentation of the pebbles he considers to be the result of contact-solution, the water being retained at these spots by capillary action."

Now, whether this theory of the origin of the pittings or little surface dimples on some of these pebbles is a probable one or not I do not discuss, but a specimen of one of the Cannock Chase pebbles I happen to possess (picked up by myself in the ballast on the London and North-Western Railway, near Lichfield, about eleven years ago) bears unmistakable evidence that the indentations upon it were produced by a squeeze or pressure; for this reason one end of the pebble (a reddish-brown quartzite, by the way) is not only severely fractured into four or five pieces, but is also miniature faulted. The lines of fracture radiate from typical indentations or dimples upon opposite sides of the pebble. Here, then, at all events, is an actual instance of a Bunter pebble not only indented by other pebbles in contact with it *in situ* in the conglomerate, but it is evident the pressure upon its sides was great enough to split it and dislocate its fragments. The once-open cracks, so produced, are now filled with calcite, which acts as a cement, holding the several portions of the pebble together. This fact supports the physical or mechanical origin of the indentations of the Bunter pebbles. Can Mr. Reade adduce *evidence* in support of the chemical theory, of which it does not appear he gave any in his paper?

Here is a sketch of one side of the particular pebble I refer to.



× = One of the indentations $\frac{5}{16}$ in. long.
×′ ×″ Lesser indentations with finer cracks in contact therewith.
c, *c*, *c*, cracks in pebble, now filled with calcite.

Note.—Corresponding indentations on opposite side in a larger one than this.

Erie, Pa., U.S.A., *7th February*, 1895. W. S. Gresley.

BUDLEIGH SALTERTON PEBBLES.

SIR,—Referring to Professor Bonney's interesting discovery [1] of schorlaceous rocks in the Budleigh Salterton pebble bed, which bed after all is but a new Red Conglomerate, it should be borne in mind that schorlaceous fragments are abundant in the breccias near Teignmouth, and elsewhere in the Red Rocks of Devonshire. It would be well to compare them, in order to ascertain, if possible, whether they have a common origin. Schorlaceous rocks, as is well known, vary greatly.

With respect to the suggestion now again brought forward by Professor Bonney that the Red Sandstones of Devonshire evidence currents from the westward,[2] the fact should not be overlooked that the mica schists found in the Bigbury Bay conglomerate, to the northward and westward of the Bolt Head, indicate transport from the south and east, harmonizes well with the commonly accepted view that many of the Budleigh Salterton fossiliferous quartzites are of southern derivation.

A. R. HUNT.

MISCELLANEOUS.

"GEOLOGICAL SOCIETY OF SOUTH AFRICA."

A largely attended meeting was held in the Chamber of Mines Board-Room, Johannesburg, Transvaal, on February 4th, 1895, for the purpose of forming a Geological Society. Dr. Hugh Exton, F.G.S., occupied the chair and addressed the meeting. The following resolutions were then moved and seconded, and carried unanimously: (1) that a Society be formed to be called "The Geological Society of South Africa"; (2) that Mr. Lionel Phillips be the first Honorary President; (3) that Professor T. Rupert Jones, F.R.S., F.G.S., and Dr. W. Guybon Atherstone, F.G.S., be Honorary Vice-Presidents; (4) that Dr. Hugh Exton, F.G.S., be the first President, and Messrs. A. R. Sawyer, F.G.S., and John Ballot, the first Vice-Presidents. (5) The Executive Council was then formed as follows: Messrs. C. Aburrow, Ed. Button, A. R. Boucher, J. S. Curtis, J. A. Chalmers, S. Farrar, F.G.S., H. D. Griffiths, A. Goerz, L. Grahame, J. Dampier Greene, J. H. Johns, E. C. Jones, E. J. B. Knox, C. Wilson Moore, W. M. Phillips, T. Reunert, E. Kemper Voss, Peregrine O. Wilson, and F. White. (6) It was unanimously resolved that Mr. David Draper, F.G.S., be appointed Secretary of the Society. It was resolved that those gentlemen who signed their names at that meeting be the first members; that the list remain open till 28th February, after which election to be by ballot.

The greatest enthusiasm prevails, and the Secretary fully anticipates that 300 members will join by the end of the month. All communications for the Society should be addressed to David Draper, Esq., F.G.S., P. O. Box 450, Johannesburg, Transvaal.

[1] GEOLOGICAL MAGAZINE, February, 1895, p. 77. [*Memo.*—"All showed tourmaline, so two of them were sliced. Both consisted mainly of granular quartz and tourmaline." Hence schorlaceous.—A. R. H.]

[2] *Ibid.* p. 79.